PRACTICAL ASTRONOMY,

IN THE

DESCRIPTION and USE

OF BOTH

GLOBES,

ORRERY

AND

TELESCOPES.

Wherein the moſt uſeful *Elements*, and moſt valuable modern *Diſcoveries* of the true ASTRONOMY are exhibited, after a very *eaſy* and *expeditious* Manner, in an exact Account of Our SOLAR SYSTEM, with Ten curious *Copper-Plates*.

Collected from the beſt AUTHORS, as Dr. *HALLET, KEIL, HARRIS, GORDON*, &c. For the USE of Young STUDENTS.

By SAMUEL FULLER.

The Works of the Lord are Great, ſought out of all them that have Pleaſure therein, Pſal. cxi. 2.

DUBLIN:

Printed by and for SAMUEL FULLER, at the *Globe* in *Meath-Street*, 1732.

THE DESCRIPTION and USE OF THE *CELESTIAL* and *TERRESTRIAL* GLOBES.

A *Globe* or *Sphere* is a round ſolid Body, having every Part of its Surface equally diſtant from a Point within it, called its *Center*; and it may be conceived to be formed by the Revolution of a Semicircle round its Diameter. *Sphere or Globe.*

Any Circle paſſing through the Center of the Sphere, thereby dividing it into two equal Parts or Segments, is called a *Great Circle*; and the Segments of the Sphere ſo divided, are called *Hemiſpheres*. *Great Circle.* *Hemiſpheres.*

Every Great Circle has its Poles and Axis.

The *Poles* of a Great Circle, are two Points on the Surface of the Sphere diametrically oppoſite to one another, and every where equally diſtant from the ſaid Circle. *Poles.*

The *Axis* of a Circle is a right Line paſſing through the Center of the Sphere, and through the Poles of the ſaid Circle; and is therefore perpendicular to the Plane thereof. *Axis.*

All Circles paſſing through the Poles of any great Circle, interſect it in two Places diametrically oppoſite, and alſo at right Angles; and with reſpect to the ſaid Great Circle, they may be called its *Secundaries*. *Secundaries.*

Parallel or leſſer Circles. All Circles dividing the Sphere into two unequal Parts, are called *leſſer* or *paralliel Circles*, and are uſually denominated by that Great Circle, to which they are parallel.

The Earth being globular, its outward Parts, as the ſeveral *Countries, Seas, &c.* are beſt, and moſt naturally repreſented upon the Superficies of a Globe; and when ſuch a Body has the outward Parts of the Earth and Sea delineated upon its Surface, and placed in their natural Order and Situation, it is called a *Terreſtrial Globe.*

Terreſtrial Globe.

The Celeſtial Bodies appear to us as if they were all placed in the ſame Concave Sphere; therefore Aſtronomers place the Stars according to their reſpective Situations and Magnitudes; and alſo the Images of the Conſtellations, upon the external Surface of a Globe; for it anſwers the Purpoſes as if they were placed within a concave Sphere, if we ſuppoſe the Globe to be tranſparent, and the Eye placed in the Center. A Globe having the Stars placed upon its Surface, as above deſcribed, is called a *Celeſtial Globe.* Theſe Globes are both placed in Frames, with other Appurtenances, as ſhall be deſcribed in a proper Place.

Celeſtial Globe.

The principal Uſes of the Globe The principal Uſes of theſe Globes, (beſides their ſerving as *Maps* to diſtinguiſh the outward Parts of the Earth, and the Situations of the fixed Stars) is to explain and reſolve the Phænomena ariſing from the diurnal Motion of the Earth round its Axis.

It is agreed on by the modern Mathematicians, that the Diſtance of the Earth from the Sun, is no more than a Point, when compared with the immenſe Diſtance of the fixed Stars; therefore let the Earth be in what Point ſoever of her Orbit, there will be the ſame Proſpect of the Heavens, as a Spectator would obſerve, did he reſide in the Sun: And if ſeveral Circles be imagined to paſs thro' the Center of the Earth, and others, parallel to them, be conceived to paſs thro' the Center of the Sun, theſe Circles in the Heavens will ſeem to coincide, and to paſs exactly thro' the ſame Stars. Wherefore as to the Appearances of the fixed Stars, it is indifferent whether the Earth or the Sun be made the Center of the Univerſe. But becauſe it is from the Earth that we always obſerve the Celeſtial Bodies, and their apparent Motions ſeem to us to be really made in the Heavens, it is more natural in explaining the Phænomena ariſing from theſe Motions, to place the Earth in the Center. And again, becauſe the Semidiameter of the Earth, when compared to her Diſtance

There will be the ſame Proſpect of the fixed Stars, whether the Spectator be placed on the Earth or in the Sun.

Diſtance from the Sun, is of no ſenſible Magnitude, any Point upon the Earth's Surface, let her be in what Part ſoever of her Orbit, may be conſidered as being the Center of the Univerſe. Upon theſe Principles, the different Phænomena ariſing from the diurnal Motion of the Earth, and the different Situation of a Spectator upon its Surface, are very naturally illuſtrated and explained by the Globes.

As to the Alterations of Seaſons, *&c.* ariſing from the annual Motion of the Earth round the Sun, it is indifferent which we ſuppoſe to move, the Earth, or the Sun; for in both Caſes, the Effect will be the ſame: Wherefore becauſe it is the Sun, that appears to us to move, we ſay the Sun is in ſuch a Part of the Ecliptic, without attributing any Motion to the Earth, any more than if ſhe had actually been at reſt. For the ſame Reaſon we ſay, the Sun riſes, or the Sun ſets; by which we mean, that he begins to appear or diſappear, without conſidering in the leaſt how theſe Effects are produced. Theſe Things are here mentioned, to obviate the Objections that are ſometimes made by Beginners, after they had been told that the Sun ſtands ſtill.

SECT. I.

An Explanation of the Circles of the Sphere, and of ſome Aſtronomical Terms ariſing therefrom.

IN Order to determine the relative Situations of Places upon the Earth, as well as the Poſitions of the fixed Stars, and other Celeſtial Phænomena; the Globe of the Earth is ſuppoſed to be environ'd by ſeveral imaginary Circles, and theſe are called, the *Circles of the Sphere*. Theſe imaginary Circles are either fixed, and always obtain the ſame Poſition in the Heavens; or moveable, according to the Poſition of the Obſerver. *The Circles of the Sphere.*

Thoſe Circles that are fixed, owe their Origine to the two-fold Motion of the Earth; and are the *Equator*, the *Ecliptic*, with their *Secundaries*, and *Parallels*. Theſe fixed Circles are uſually delineated upon the Surface of the Globes.

The moveable Circles are only the *Horizon*, its *Secundaries* and *Parallels*: Theſe are repreſented by the Wooden-Frame, and

the Brass-Ring, wherein the Globe is hung, and a thin Plate of Brass to be screwed in a proper Place upon the said Ring, as Occasion requires.

I. *Of the Equinoctial.*

The Equator or Equinoctial.

I. The *Equator* or the *Equinoctial*, is that Great Circle in the Heavens, in whose Plane the Earth performs its diurnal Motion round its Axis; or it is that Great Circle, parallel to which the whole Heavens seem to turn round the Earth from East to West in 24 Hours.

Note, The Equator and the Equinoctial are generally synonomous Terms; but sometimes the Equator particularly signifies that Great Circle upon the Surface of the Earth, which coincides with the Equinoctial in the Heavens. This Circle is also by Mariners commonly called the *Line*.

The Equinoctial divides the Globe of the Earth, and also the whole Heavens into two equal Parts, North and South, which are called the *Northern* and *Southern Hemispheres*. The Axis of this Circle is called the *Axis of the World*, or the *Earth's Axis*, because the Earth revolves about it (from West to East) in 24 Hours. The Extremes of this Axis are called the *Poles* of the *World*, whereof that which lies in the Northern Hemisphere, is called the *North-Pole*, and the other is called the *South-Pole*.

Northern and Southern Hemispheres.

The Axis of the World.

Poles of the World, or of the Equator.

The Equinoctial-Circle is always delineated upon the Surface of each Globe, with its Name at length expressed; the Axis of this Circle or the Earth's Axis, is only an imaginary Line in the Heavens, but on the Globes it is expressed by the Wires about which they really turn. The Poles of the World are the two Points upon the Surface of the Globe through which these Wires pass; the North Pole is that which hath the little brass Circle, with a moveable Index placed round it; and the other opposite to it, is the South Pole. The Northern Hemisphere is that wherein the North Pole is placed, and the opposite one is the Southern Hemisphere.

The Astronomers divide all Circles into 360 equal Parts called *Degrees*, each Degree into 60 equal Parts called *Minutes*, each Minute into 60 Seconds, *&c.* But besides this Division into Degrees, the Equinoctial is commonly divided into 24 equal Parts or *Hours*, each Hour into 60 *Minutes*, each Minute into 60 *Seconds*. *&c.* so that one Hour is equal to 15 Degrees, each Minute of Time is equal to 15 Minutes of a Degree, *&c.*

2. All

2. All Circles conceived to pass through the Poles of the World, intersecting the Equinoctial at Right-Angles, are with respect to any Point in the Heavens called *Hour-Circles*; and also *Circles* of *Ascension*, because the Ascension of the Heavenly Bodies, from a certain Point, are by them determined.

Hour Circles, or Circles of Ascension, also called Meridians.

These Circles are also with regard to Places upon the Earth, call'd *Meridians*.

The *Meridians* are commonly drawn upon the Terrestrial Globe thro' every 15 Degrees of the Equinoctial, thereby making an Hour difference betwixt the Places through which they pass. On the Celestial Globe there are commonly drawn but two of these *Meridians* crossing the Equinoctial in four Points equidistant from one another, thereby dividing it into four Quadrants; but the intermediate ones are here supplied, and also upon the Terrestrial Globe, by the Brass Circle in which they are hung, which is therefore called the *Brass Meridian*, and sometimes only the *Meridian*; it serving for this purpose to all the Points upon either Globe.

The Brass Meridian.

There is also a little Brass Circle fixed upon this Meridian, divided into 24 Hours, having an Index moveable round the Axis of the Globe to be turned to any particular Hour. The Use of this Circle is to shew the Difference of Time betwixt any two Meridians, and is therefore called the *Hour-Circle*.

The Hour Circle.

3. All Circles parallel to the Equinoctial, are with respect to any Point in the Heavens, called *Parallels* of *Declination*. So that,

Parallels of Declination.

4. The *Declination* of any *Point* in the Heavens (as the *Sun*, a *fixed Star*, or the like) is an Arch of the Meridian passing through that Point, and intercepted betwixt it and the Equator: And if the said Point be to the

{Northward / Southward} of the Equator, it is called {*North* / *South*} *Declination.*

Declination North or South.

Of the Parallels of Declination, four are eminently distinguished by particular Names, *viz.* The two *Tropics*, and the two *Polar Circles*.

Tropics and Polar Circles.

5. The Tropics are on different Sides of the Equator, each 23 Degrees and 29 Minutes distant from it; that which lies in the Northern Hemisphere, is called the *Tropic of Cancer*; and the Southern one, the *Tropic of Capricorn*.

Tropics of Cancer; of Capricorn.

These

Theſe Circles are the Limits of the Sun's greateſt Declination, and are called Tropics, becauſe whenever the Sun arrives to them; he ſeems to return back again towards the Equator.

6. The *Polar Circles* are each of them at the ſame Diſtance from the Poles of the World, that the Tropics are from the Equator, *viz.* 23° 29′. That which lies near the North Pole, is called the *Arctic Circle*, from *Arctos* a Conſtellation ſituated in the Heavens near that Place; whence alſo this Pole is ſometimes called the *Arctic Pole*. The other Polar Circle, which is ſituated near the South Pole, is called the *Antarctic Circle*; becauſe its Poſition is contrary to the other: And the South Pole is ſometimes called the *Antartic Pole*.

Arctic Circle.

Arctic Pole.

Antartic Circle.

The Tropics and the Polar Circles have each their Names expreſſed upon the Globes.

II. *Of the Ecliptic.*

Ecliptic.

7. The *Ecliptic* is that great Circle in whoſe Plane the Earth performs its annual Motion round the Sun; or, in which the Sun ſeems to move round the Earth once in a Year: This Circle makes an Angle with the Equinoctial of 23 Degrees 29 Minutes; and interſects it in two oppoſite Points, which are called the *Equinoctial Points*; and the two Points in the Ecliptic that are at the greateſt Diſtance from the Equinoctial Points, are called the *Solſtitial Points*. The two Meridians paſſing through thoſe Points, are by Way of Eminence, called *Colures*; whereof that which paſſeth thro' the Equinoctial Points is called the *Equinoctial Colure*; and that which is at Right-Angles to it paſſing through the Solſtitial Points, is called the *Solſtitial Colure*.

Equinoctial Points.

Solſtitial Points.

Colures.

Equinoctial Colure.

Solſtitial Colure.

The Ecliptic divided into Signs.

The Ecliptic is divided into 12 equal Parts called *Signs*, each Sign being 30 Degrees, beginning from one of the Equinoctial Points, and numbered from Weſt to Eaſt: The Names and Characters of the 12 Signs are as follow: *viz.*

Aries,	*Taurus*,	*Gemini*,	*Cancer*,	*Leo*,	*Virgo*,
1. ♈	2. ♉	3. ♊	4. ♋	5. ♌	6. ♍
Libra,	*Scorpio*,	*Sagittarius*,	*Capricornus*,	*Aquarius*,	*Piſces*.
7. ♎	8. ♏	9. ♐	10. ♑	11. ♒	12. ♓

Northern Signs.

The firſt ſix of theſe are called the *Northern Signs*, and poſſeſs that Half of the Ecliptic which is to the

the Northward of the Equator; beginning with the first Point of ♈, and ending with the last Point of ♍.

The latter Six are called the *Southern Signs*, because they possess the Southern Half of the Ecliptic, beginning at the first Point of ♎, and ending with the last Point of ♓. *Southern Signs.*

The Division of the Ecliptic into Signs, and the Names of the Colures, are particularly expressed upon the Globes.

The Signs of the Ecliptic took their Names from 12 Constellations situated in the Heavens near those Places. It is to be observed, that the Signs are not to be confounded with the Constellations of the same Name: For the *Sign* of *Aries* is not the same with the *Constellation Aries*; the latter is a System of Stars digested into the Figure of a *Ram*; but the Sign of *Aries* is only 30 Degrees of the Ecliptic counted from the Equinoctial Point ♈, (which is reckon'd the first Point in the Ecliptic) to the Beginning of *Taurus*: Or, it is sometimes taken for all that Space upon the Celestial Globe contained between the two Circles passing through the first Points of ♈ and ♉. What has been here said of *Aries*, is to be noted of all the rest of the Signs.

The Constellations abovementioned were formerly situated within the Signs, which now bear their Names; but by a slow Motion of the Equinoctial Points, being one Degree in 72 Years, the Constellation *Aries* has now got into the Sign ♉, and so of the rest. So that *Pisces* is now got into the Sign of ♈; this slow Motion in the Heavens is called the *Precession of the Equinoxes*. By this Motion, that Star, which we now call the *Pole Star* will in process of Time be to the Southward of *London*.

The *Poles of the Ecliptic* are both situated in the Solstitial Colure, at 23 Degrees, 29 Minutes Distance from the Pole of the World; and they take their Denomination from the Hemisphere wherein they are placed, *viz.* that which lies in the *Poles of the Ecliptick.*

{Northern / Southern} Hemisphere, is called the {North / South} Pole of the Ecliptic.

The Arctic and Antarctic Circles are described by the Poles of the Ecliptic in the Diurnal Motion of the Earth round its Axis, whence it seems these two Circles are called *Polar*.

8. All great Circles passing through the Poles of the Ecliptic, (and consequently intersecting it at Right-Angles) are called *Circles* of *Longitude*: So that *Circles of Longitude.*

9. The

Longitude of any Point in the Heavens. 9. The *Longitude* of any *Point* in the Heavens, (as a *Star* or *Planet*, &c.) is an Arch of the Ecliptic contained between the Circle of Longitude passing thro' that Point, and the Equinoctial Point ♈. And that degree of any Sign which lies under the Circle of Longitude, passing thro' any Star or Planet, is called the *Place* of that Star or Planet.

Place of a Star.

Note; The *Sun* never goes out of the Ecliptic, and it is not usual to say the Sun's Longitude, but we commonly express it the *Sun's Place*, which is that Sign, Degree, Minute, *&c.* of the Ecliptic, which he at any time possesses.

10. All Circles conceived to be drawn parallel to the Ecliptic, are called *Parallels* of *Latitude*: So that,

Latitude of a Star, &c. 11. The *Latitude* of any Point in the Heavens, (as a fixed Star, *&c.*) is an Arch of the Circle of Longitude, passing thro' that Point, and intercepted betwixt it and the Ecliptic; or, the Latitude is the Distance from the Ecliptic: And if the said Point be to the Northward of the Ecliptic, it is called North-Latitude; but if it be to the Southward, it is called South-Latitude.

Upon the *Terrestrial Globe* none of the Circles of Longitude are described; and upon the *Celestial*, they are commonly drawn thro' the Beginning of every *Sign*; but they are all supplied upon both Globes, by fastening a thin Plate of Brass over one of the Poles of the Ecliptic, and so as to be moved to any Degree thereof at pleasure. The Parallels of Latitude are also supplied by the Graduations upon the said Plate, as shall be shewed in a proper Place.

We have now done with all those Circles that are fixed, and such as are drawn upon the Globes themselves; we next proceed to the moveable Circles.

III. *Of the Horizon.*

Horizon. 12. The *Horizon* is that great Circle which divides the upper or visible Hemisphere of the World, from the lower or invisible: This Circle is distinguished into two Sorts, the *Sensible* and the *Rational*.

Sensible Horizon. The *Sensible* or *Apparent Horizon* is that Circle which limits or terminates our Prospect, whether we are at Land or Sea, reaching as far as we can see; or it is that Circle where the Sky and the Earth or Water seem to meet. When we are on *Terra Firma*, this Circle commonly seems rugged and irregular, occasion'd by the unevenness of the Ground terminating our Prospect; but at Sea there are no such Irregularities. The Semidiameter of this

this Circle varieth according to the Heighth of the Eye of the Obſerver; if a Man of Six Foot high ſtood upon a large Plane, or the Surface of the Sea, he could not ſee above three Miles round.

The *Senſible* or *Apparent Horizon* is the Extremity of the Earth, that bounds our Sight, which for the moſt part is uneven; and at Sea is of a greater or leſs extent, as the Eye is higher or lower: And ſuppoſing a Degree of the Circumference of the Earth to be 365000 Feet, *London*-Meaſure, (as agreeing with the moſt accurate Obſervations yet made) then will the Circumference be 26280 Miles, each of 5000 Feet, and conſequently the Semi-diameter of the Earth will be about 4365, 188 Miles.

And therefore the Eye, at the Heighth of 5 Feet above the Surface of the Water, will ſee but 2, 262 Miles off: at 20 Feet high, 5, 784 Miles: at 50 Feet, 9, 146 Miles, and at 100 Feet high, 12, 932 Miles every way: Or generally, putting *d* for the Diameter of the Earth, and *h* for the Heighth of the Eye above the Surface of the Water, the Semi-diameter of the *Senſible Horizon* will be equal to $\sqrt{d+h \times h}$.

Tho' the Riſing and Setting of the Stars reſpect the *Rational Horizon*, yet by Reaſon of their vaſt Diſtance, it holds true of the *Senſible*, which is more than 4000 Miles above it.

This Circle determines the Riſing and Setting of the heavenly Bodies, and diſtinguiſhes Day and Night.

Rational Horizon.

The *Rational* or true *Horizon* is a great Circle paſſing thro' the Center of the Earth parallel to the ſenſible Horizon, being diſtant from it by the Earth's Semi-diameter, which is nothing in Compariſon of the immenſe Diſtance of the Sun and the fixed Stars, therefore Aſtronomers make no Diſtinction between theſe two Circles, but conſider the apparent Horizon, or that wherein the Sun appears to riſe and ſet, as paſſing thro' the Center of the Earth.

This Circle is divided by Aſtronomers into four Quadrants, and each of theſe Quadrants into 90 Degrees, *&c.*

Cardinal Points of the Horizon.

The Four Points quartering this Circle are call'd the *Cardinal Points*, and are termed the *Eaſt*, *Weſt*, *North* and *South*. The *Eaſt* is that Point of the Horizon where the Sun riſes when he is in the Equinoctial; or on that Day when he aſcends above the Horizon exactly at Six o' Clock; and the *Weſt* is that Point of the Horizon which is directly oppoſite to the *Eaſt*, or where the Sun ſets, when he is in the Equinoctial. The *South* is 90 Degrees diſtant from the *Eaſt* and *Weſt*, and is towards that part of the Heavens wherein the Sun always appears to us in *Great Britain* at Noon; and

the *North* is that Part of the Heavens which is directly oppoſite to the *South*. Or the North and South Points of the Heavens may be found by turning your ſelf directly either towards the Eaſt or the Weſt: If you look towards the

(East / West) the (South / North) will be to the right Hand, and the (North / South) to the Left.

Points of the Compaſs. Beſides the aforementioned Diviſion of the Horizon into Degrees, *Mariners* divide it into 32 equal Parts, which they call the *Points* of the *Compaſs*; to each of which Points they give a particular Name, compounded of the four Cardinals, according to what Quarter of the Compaſs is intended.

The Center of the Horizon is the Place of Obſervation, and the Poles of it are, one exactly over our Heads, *Zenith.* called the *Zenith*; and the other exactly under our *Nadir.* Feet called the *Nadir.*

13. All Circles conceived to paſs thro' the Zenith and Nadir, are called *Vertical Circles*, or *Azimuths*. Of theſe Circles, that which paſſes thro' the North and South Points of the Horizon is *Meridian.* called the *Meridian*; ſo that when any Object is upon the Meridian, it then bears either due South *Azimuth.* or due North from us; and the *Azimuth* of any Object is an Arch of the Horizon intercepted between the Vertical Circle paſſing thro' it, and either the North or South part of the Meridian; which Part is commonly ſpecified.

The Meridian paſſes thro' the Poles of the World, as well as thro' the Zenith and Nadir, and therefore is a Secundary both of the Equinoctial and the Horizon: This Circle divides the Globe into the *Eaſtern* and *Weſtern Hemiſpheres*; and the *Poles* of it are the *Eaſt* and *Weſt* Points of the *Horizon*. All the heavenly Objects are during one half of their Continuance above the Horizon, in the Eaſtern Hemiſphere, and for the other half in the Weſtern; ſo that whenever the Sun arrives upon the upper part of the Meridian, it is then *Noon* or *Mid day*, which is the reaſon why this Circle is called the Meridian; and when he comes to the lower part, it is then *Mid-night*.

The Vertical Circle paſſing thro' the Eaſt and *Prime-Vertical.* Weſt of the Horizon, is called the *Prime-Vertical*, or *Circle* of *Eaſt* and *Weſt*: ſo that when any Object is upon this Circle in the Eaſtern Hemiſphere, it appears due Eaſt; and if it be in the Weſtern Hemiſphere it appears due Weſt.

That

That Degree in the Horizon wherein any Object rises and sets from the East or West Points is called the *Amplitude*; which for rising is called *Amplitude Ortive* and *Occasive* for Setting; which must be also denominated, whether it be Northerly or Southerly. *Amplitude.*

It may be observed, that the *Amplitude* and *Azimuth* are much the same; the Amplitude shewing the bearing of any Object when he rises or sets, from the East or West Points of the Horizon; and the Azimuth the bearing of any Object, when it is above the Horizon, either from the North or South Points thereof. As for Example, if an Object rises or sets within 10 Degrees of the East or West, suppose towards the South, we accordingly say its *Amplitude* is 10 Degrees Southerly; but if an Object, that is of any Height above the Horizon should be in the Vertical Circle passing thro' the aforementioned Point, we then say, its *Azimuth* is 80 Degrees from the South, or 100 Degrees from the North, both which Expressions signify the same.

14. All Circles drawn parallel to the Horizon, in the upper Hemisphere, are called *Almicanters*, or *Parallels of Altitude*: So that the *Altitude* of any Point in the Heavens is an Arch of the Vertical Circle passing thro' that Point, and intercepted betwixt it and the Horizon: and if the Object be upon the Meridian, it is commonly called the *Meridian Altitude*. The Complement of the Altitude, or what it wants of 90 Degrees, is called the *Zenith Distance*. *Almicanters.* *Altitudes.* *Meridian Altitude.* *Zenith Distance.*

The Horizon (by which we mean the Rational) is represented by the upper Surface of the Wooden Frame wherein the Globes are placed; upon this Horizon are described several Concentric Circles the innermost of which is divided into four times 90 Degrees, beginning at the East and the West Points, and counted both ways to the North and South, where they end at 90 Degrees. The Use of these Divisions is to shew the Amplitudes of the Sun and Stars at their Rising and Setting: Also in some convenient Place upon this Horizon, there are commonly noted the Points of the Compass. Without the aforemention'd Circle, there is drawn the Ecliptic, with its Divisions into Signs and Degrees, and a Circle of Months and Days: The Use of these two Circles is to serve as a *Calendar* to shew the Sun's Place at any time of the Year; and by that means to find his Place in the *Ecliptic* drawn upon the Globe it self.

The *Vertical Circles*, and the *Parallels of Altitude*, are supplied by a thin Plate of Brass, having a Nut and Screw at one end, to fasten it to the Brass Meridian in the Zenith Point; which being

ing done, the lower End of it may be put between the Globe it ſelf and the inner Edge of the Horizon, and ſo turned round about to any Point required. The fiducial Edge thereof repreſenting the *Vertical Circles*, and the *Degrees* upon it, deſcribing the Parallels of Altitude. This thin Plate is called the *Quadrant of Altitude*.

Quadrant of Altitude.

The Center of the Horizon being the Place of Obſervation, it is evident, that this Circle, and all the others belonging to it, are continually changed which way ſoever we move; wherefore we may ſuppoſe the Horizon, with its Secundaries and Parallels, to inveſt the Globe like a *Rete* or Net; and to be moveable every way round it. This is very naturally illuſtrated by the Globes; if we move directly North or directly South, the Change made in the Horizon is repreſented, by moving the Braſs Meridian (keeping the Globe from turning about its Axis) in the Notches made in the Wooden Horizon juſt ſo much as we travelled. If our Courſe ſhould be due Eaſt or due Weſt, the Alterations made thereby are repreſented, by turning the Globe accordingly about its Axis, the Braſs Meridian being kept fixed; and if we ſteer betwixt the Meridian and the Eaſt or Weſt Points, then we are to turn the Braſs Meridian, and alſo the Globe about its Axis accordingly. The Sum of which is: Let the Spectator be in what Point ſoever of the Earth's Surface, he'll there gravitate or tend exactly towards its Center, and imagin himſelf to be on the higheſt Part thereof, (the unevenneſs of the Ground not being here conſidered:) wherefore if we turn the Globe in ſuch a manner, as to bring the ſeveral Progreſſive Steps of a Traveller ſucceſſively to the Zenith, we ſhall then have the ſucceſſive Alterations made in the Horizon, in every Part of his Journey. This Explication being well conſidered, will be of help to Beginners to conceive how the Earth is every where habitable, and how Paſſengers can travel quite round it: For ſince every thing tends towards the Center of the Earth, we are to conceive that Point as being the loweſt, and not to carry our Idea of downwards any farther: Thoſe that are diametrically oppoſite to us, being as much upon the upper part of the Earth as we are; there being no ſuch thing in Nature, as one Place being higher than another, but as it is at a greater diſtance from the Center of the Earth, let it be in what Country ſoever.

We have now done with all the Circles of the Sphere, and it may be obſerved, that the *Equinoctial*, the *Ecliptic*, and the *Horizon*, with their Secundaries and Parallels, are all alike; and altering their Poſition, may be made to ſerve for one another. Thus, If the *Poles* of the *World* be brought into the *Zenith* and *Nadir*;

Nadir; the *Equinoctial* will coincide with the *Horizon*, the *Meridians* will be the ſame with the *Vertical Circles*, and the Parallels of *Declination* will be the Parallels of *Altitude*. After the ſame manner, if ſhifting the Poſition we bring the *Ecliptic* to coincide with the *Horizon*; the Circles of *Longitude* will be the *Vertical Circles*, and the Parallels of *Latitude* and *Altitude* will coincide.

The Horizon and the Equator may be either Parallel, Perpendicular, or Oblique to each other.

15. A *Parallel Sphere* is that Poſition where the Equator coincides with the Horizon, and conſequently the Poles of the World are in the Zenith and Nadir: The Inhabitants of this Sphere (if there be any) are thoſe who live under the Poles of the World. *Parallel Sphere.*

16. A *Right or Direct Sphere* is that Poſition, where the Equator is perpendicular to the Horizon; the Inhabitants whereof are thoſe who live under the Equinoctial. *Right Sphere.*

17. An *Oblique Sphere* is when the Equinoctial and the Horizon make Oblique Angles with each other; which every where happens, but under the Equator and the Poles. *Oblique Sphere.*

The Arch of any Parallel of Declination which ſtands above the Horizon, is called the *Diurnal Arch*; and the remaining part of it, which is below the Horizon, is called the *Nocturnal Arch*. *Diurnal and Nocturnal Arch.*

That Point of the Equinoctial which comes to the { Eaſtern / Weſtern } Part of the Horizon, with any Point in the Heavens, is called the { Aſcenſion / Deſcenſion } of that Point, counted from the Beginning of ♈; and if it be in a Right Sphere, the Aſcenſion or Deſcenſion is called Right; but if it be in an Oblique Sphere, it is called Oblique Aſcenſion or Deſcenſion.

So that,

18. The *Right Aſcenſion* of the *Sun*, *Moon*, or any *Star*, *&c.* is an Arch of the Equator contained betwixt the Beginning of ♈, and that Point of the Equinoctial which riſes with them in a *Right Sphere*; or which comes to the Meridian with them in an Oblique Sphere. *Right Aſcenſion.*

19. *Oblique Aſcenſion* or *Deſcenſion*, is an Arch of the Equinoctial intercepted betwixt the Beginning of ♈, and that *Point* of the *Equator* which riſes or ſets with any Point in the Heavens in an Oblique Sphere. *Oblique Aſcenſion.*

20. *Aſcenſional Difference* is the Difference betwixt the *Right* and Oblique Aſcenſion or Deſcenſion; and ſhews how long the Sun riſes or ſets before or after the Hour of Six. *Aſcenſional Difference.*

IV.

IV. *Of the Division of Time.*

The Parts that Time is distinguished into, are *Days*, *Hours*, *Weeks*, *Months* and *Years*.

A Day is either Natural or Artificial.

Natural and Artificial Day.

A *Natural Day* is the Space of Time elapsed, while the Sun goes from any Meridian or Horary Circle, till he arrives to the same again; or, it is the Time contained from Noon or any particular Hour, to the next Noon or the same Hour again: An *Artificial Day*, is the Time betwixt the Sun's Rising and Setting, to which is opposed the *Night*, that is, the Time the Sun is hid under the Horizon.

Hours, &c.

The *Natural Day* is divided into 24 *Hours* each Hour into 60 *Minutes*, each Minute into 60 *Seconds*, *&c.* The *Artificial Days* are always unequal to all the Inhabitants that are not under the Equator, except when the Sun is in the Equinoctial Points ♈ and ♎, which happens (according to our way of reckoning) about the 10th of *March* and 12th of *September*; at those Times the Sun rises at six, and sets at six, to all the Inhabitants of the Earth.

Equinoxes.

These Days are called the *Equinoxes* or Equinoctial Days; the first of which, or when the Sun is in the first Point of *Aries*, is called the *Vernal Equinox*, and the latter is called the *Autumnal Equinox*. At all other times of the Year, the Days continually lengthen or shorten and that faster or slower according as the Sun is nearer to or further from the Equinoctial, until he arrives to either of the *Solstitial Points* ♋ or ♑. At those Times the Sun seems to stand still for a few Days, and then he begins to return with a slow Motion towards the Equinoctial, still hastning his Pace as he comes nearer to it: The Sun enters the Tropics of ♋ and ♑, about the 10th of *June* and the 11th of *December*, which Days are sometimes called the *Solstices*; the first of which we call the *Summer Solstice*, and the latter the *Winter-Solstice*.

Vernal and Autumnal Equinox

Solstices. Summer and Winter Solstice

The different Beginning of the Day

All Nations do not begin their Day, and reckon their Hours alike. In *Great-Britain*, *France* and *Spain*, and in most Places in *Europe*, the Day is reckoned to begin at Midnight, from whence are counted 12 Hours till Noon, then 12 Hours more till Midnight, which make a complete Day: Yet the *Astronomers* (in these Countries) commonly begin their Day at Noon, and so rec-

reckon 24 Hours till next Noon, and not twice twelve, according to the vulgar Computation.

The *Babylonians* began their Day at Sun-rising, and reckoned 24 Hours till he rose again: this way of Computation we call the *Babylonish Hours*. In several Parts of *Germany* they count their Hours from Sun setting, calling the first Hour after the Sun has set, the first Hour, *&c.* till he sets the next Day, which they call the 24th Hour: these are commonly called the *Italian Hours*. According to both these ways of Computation, their Hours are commonly either a little greater or less than the $\frac{1}{24}$ part of a natural Day, in Proportion as the Sun rises or sets sooner or later in the succeeding Days: They have also this Inconvenience, that their Mid-day and Mid-night happen on different Hours, according to the Seasons of the Year. Babylonish *Hours.* Italian *Hours.*

The *Jews* and the *Romans* formerly, divided the *Artificial* Days and Nights each into 12 equal Parts; these are termed the *Jewish Hours*, and are of different Lengths according to the Seasons of the Year, a Jewish Hour in Summer, being longer than one in Winter, and a Night Hour shorter. This Method of Computation is now in Use among the *Turks* and the Hours are styled the *first Hour, second Hour, &c.* of the Day or Night; so that *Mid-day* always falls upon the sixth Hour of the Day. These Hours are also called *Planetary Hours*; because in every Hour one of the Seven Planets was supposed to preside over the World, and so take it by turns. The first Hour after Sun rising on Sunday was allotted to the *Sun*; the next to *Venus*; the third to *Mercury*; and the rest in order to the *Moon, Saturn, Jupiter*, and *Mars*. By this means on the first Hour of the next Day, the Moon presided, and so gave the Name to that Day; and so seven Days by this Method had Names given them from the Planets that were supposed to govern on the first Hour. Jewish *Hours* Planetary *Hours*

A *Week* is a System of seven Days, in which each Day is distinguished by a different Name. In most Countries, these Days are called after the Names of the Seven Planets, as above noted. All Nations that have any Notion of Religion, set apart one Day in seven for public Worship; the Day solemnized by *Christians* is Sunday, or the first Day of the Week, being that on which our Saviour rose from the Grave, on which the Apostles afterwards used more particularly to assemble together to perform divine Worship. The *Jews* observed Saturday, or the seventh Day of the Week, for their Sabbath or Day of Rest, being that appointed *A Week.*

in

in the fourth Commandment under the Law. The *Turks* perform their religious Ceremonies on Friday or the 6th Day of the Week.

A Month. A Month is properly a certain Space of Time meaſured by the Moon in its Courſe round the Earth. A *Lunar* Month is either *Periodical* or *Synodical.* A *Periodical Month* is that Space of Time the Moon takes to perform her Courſe from one Point of the Ecliptic till ſhe arrives to the ſame again; which is 27 Days and ſome odd Hours: And a *Synodical Month* is the Time betwixt one new Moon and the next new Moon, which is commonly about 29½ Days, But a *Civil Month* is different from theſe, and conſiſts of a certain Number of Days, fewer or more, according to the Laws and Cuſtoms of the Country wherein they are obſerved.

Periodical and Synodical Months

The completeſt Period of Time is a *Year*, in which all the Variety of Seaſons return, and afterwards begin a-new. A *Year* is either *Aſtronomical* or *Civil.* An *Aſtronomical Year* is either a *Sydereal*, wherein the Sun departing from a fixed Star, returns to it again; or, *Tropical*, which is the Space of Time the Sun takes to perform its Courſe from any Point of the Ecliptic till he returns to it again.

A Year Sydereal and Tropical.

A *Tropical Year* conſiſts of 365 Days, 5 Hours, and 49 Minutes; this is the Time in which all the Seaſons completely return, which is a ſmall matter leſs than a Sydereal Year.

The *Civil Year* is the ſame with the *Political* eſtabliſhed by the Laws of a Country, and either moveable or immoveable. The moveable Year conſiſts of 365 Days, being leſs than the Tropical Year by almoſt ſix Hours; and is called the *Egyptian Year*, becauſe obſerved in that Country.

Egyptian Year.

The *Romans* divided the Year into 12 Kalendar Months, to which they gave particular Names, and are ſtill retained by moſt of the *European* Nations, *viz. January, February, March, April, May, June, July, Auguſt, September, October, November* and *December.* The Number of Days in each Month may be known by the following Verſes:

Thirty Days hath September,
April, June, *and* November;
February *hath Twenty-Eight alone,*
And all the reſt have Thirty One.

The

The Year is alſo divided into four Quarters or Seaſons, *viz.* The *Spring*, *Summer*, *Autumn* and *Winter*. Theſe Quarters are properly made, when the Sun enters into the Equinoctial and Solſtitial Points of the Ecliptic: But in civil Uſes they are differently reckon'd, according to the Cuſtoms of ſeveral Countries. In *England* we commonly reckon the firſt Day of *January* to be the firſt in the Year, which is therefore vulgarly called *New-year's-Day*; but in Political and Eccleſiaſtical Affairs, the Year is reckoned to commence on *Lady-Day*, (ſo called) which is the 25th of *March*; and from thence to *Midſummer-Day*, which is the 24th of *June*, is reckoned the firſt Quarter; from *Midſummer-Day* to *Michaelmas-Day*, which is the 29th of *September*, is the ſecond Quarter; the third Quarter is reckon'd from *Michaelmas-Day* to *Chriſtmas-Day*, which is the 25th of *December*; and from *Chriſtmas-Day* to *Lady-Day*, is reckoned the laſt Quarter in the Year. In common Affairs, a Quarter is reckoned from a certain Day to the ſame in the fourth Month following. Sometimes a Month is reckoned four Weeks or 28 Days, and ſo a Quarter 12 Weeks. To all the Inhabitants in the {Northern / Southern} Hemiſphere, their *Midſummer* is properly when the Sun appears in the Tropic of {*Cancer* / *Capricorn*} and their *Midwinter* the oppoſite Time of the Year. But thoſe who live under the Equinoctial, have two *Winters*, *viz.* when the Sun is in either Tropic; tho' indeed properly there is no Seaſon that may be called *Winter* in thoſe Parts of the World.

The *Egyptian* Year of 365 Days, being leſs than the true Solar Year, by almoſt ſix Hours, it follows that four ſuch Years are leſs than four Solar Years, by a whole Day; and therefore in 365 times four Years, that is, in 1460 Years, the Beginning of the Years moves through all the Seaſons. To remedy this Inconveniency, *Julius Cæſar* (conſidering that the ſix Hours which remain at the End of every Year, will in four Years make a natural Day) ordered that every fourth Year ſhould have an intercalary Day, which therefore conſiſts of 366 Days; the Day added was put in the Month of *February*, by poſtponing St. *Matthias*'s Day, which in common Years falls on the 24th, to the 25th of the ſaid Month: All the fixed Feaſts in the Year from thenceforwards falling a Week-day later than otherwiſe they would.

Biſſextile or Leap-Year.

According to the *Roman* Way of reckoning, the 24th of *February* was the ſixth of the Kalends of *March*, and it was ordered that for this Year there ſhould be two Sixths, or that the Sixth of the Kalends

of *March* ſhould be twice repeated; upon which Account the Year was called *Biſſextile*, which we now call the *Leap-year*.

To find whether the Year of our Lord be Leap-Year, or the Firſt, Second, or Third after; divide it by four, and the Remainder, if there be any, ſhews how many Years it is after Leap-Year; but if there be no Remainder, then that Year is Leap-Year: Or, omit the Hundreds and Scores, and divide the Reſidue by 4. *Example*, 1731, omitting the Hundreds and the Twenty, I divide the Reſidue 11 by 4, and the Remainder 3, ſhews it to be the Third after Leap-Year.

This Method of reckoning the Year, *viz.* making the common Year to conſiſt of 365 Days, and every fourth Year to have 366 Days, is now uſed in *Great-Britain* and *Ireland*, and ſome of the Northern Parts of *Europe*, and is called the *Julian Account*, or the *Old Style*. But the Time appointed by *Julius Cæſar* for the Length of a Solar Year is too much; for the Sun finiſhes his apparent Courſe in the Ecliptic in 365 Days, 5 Hours, and 49 Minutes, which is 11 Minutes leſs than the Civil Year; and therefore he again begins his Circuit 11 Minutes before the Civil Year is ended: And ſo much being gained every Year, amounts in 131 Years to a whole Day. So that if the Sun in any Year entred the Equinox upon the 20th of *March* at Noon, after the Space of 131 Years, he'll enter the ſame Point on the ſame Hour of the 19th of *March*. And therefore the Equinoxes will not always fall on the ſame Day of the Month, but by degrees will move towards the Beginning of the Year.

Julian *Account*, *or the* Old Style.

At the Time of the *Council of Nice*, (when the Terms were ſettled for Obſerving of *Eaſter*) the *Vernal Equinox* fell upon the 21ſt of *March*; but by its falling backwards 11 Minutes every Year, it was found that in *Anno* 1582, when the Kalendar was corrected, the Sun entred the Equinoctial Circle on the 11th of *March*, having departed ten whole Days from its former Place in the Year: And therefore Pope *Gregory* the XIIIth deſigning to place the Equinoxes in their former Situation with reſpect to the Year, took theſe ten Days out of the Kalendar, and order'd that the Eleventh of *March* ſhould be reckon'd as the Twenty-firſt: And to prevent the Seaſons of the Year from going backwards for the Future, he ordered that every hundredth Year, which in the *Julian* Form was to be a *Biſſextile*, ſhould be a common Year, and conſiſt only of 365 Days; but that being too much, every fourth Hundred was to remain *Biſſextile*. This Form of reckoning being eſtabliſhed by the Authority of Pope *Gregory* XIII. is called the *Gregorian Account*, or the *New Style*; and is obſerved in all the Countries where the Authority

Gregorian *Account*, or New Style.

Authority of the Pope is acknowledged, and likewiſe, by ſeveral Nations of the reformed Religion. There being now above a hundred Years paſt, ſince this Reformation was made in the Kalendar, the *Gregorian* Account has accordingly got before the *Julian* one Day more than it was at the Time of its Inſtitution, the Difference between theſe two Accounts being now eleven Days; ſo that the firſt Day of any Month, according to our Way of reckoning, is the 12th of the ſame Month according to the New Style.

I ſhall conclude this *Section* with a brief Account of the *Atmoſphere*.

The *Atmoſphere* is that thin Body of Air which furrounds the Earth, in which the Clouds hover, and by which in their Deſcent they are broke into Drops of Rain; which ſometimes, according to the Warmth or Coldneſs of the Air, are froze into *Snow*, or *Hailſtones*. *Thunder* and *Lightning* are alſo made in the *Atmoſphere*; and Wind is nothing elſe but a Percuſſion of the Air, occaſion'd by its different Denſity in different Places. The Benefits we receive from the *Atmoſphere* are innumerable; without Air no earthly Creature could live, as is plainly proved by Experiments made by the *Air-Pump*; and the Wholeſomneſs of a Climate chiefly depends upon that of its Air: If there was no *Atmoſphere* to reflect the Rays of the Sun, no Part of the Heavens would be lucid and bright, but that wherein the Sun was placed; and if a Spectator ſhould turn his Back towards the Sun, he would immediately perceive it to be quite dark, and the leaſt Stars would be ſeen ſhining as they do in the cleareſt Night; and the Sun immediately before his ſetting would ſhine as briſk as at Noon: But in a Moment, as ſoon as he is got below the Horizon, the whole *Hemiſphere* of the Earth would be involved in as great a Darkneſs, as if it were Midnight. Atmoſphere.

But by Means of the *Atmoſphere*, it happens that while the Sun is above the Horizon, the whole Face of the Heavens is ſtrongly illuminated by its Rays, ſo as to obſcure the faint Light of the Stars and render them inviſible; and after Sun-ſetting, though we receive no direct Light from him, yet we enjoy its reflected Light for ſome Time: For the *Atmoſphere* being higher than we are, is a longer Time before it is withdrawn from the Sun. (as if a Man was to run up to the Top of a Steeple, he may ſee the Sun after it had been ſet to thoſe at the Bottom.) The Rays which the *Atmoſphere* receives from the Sun. after he is withdrawn from our Sight, are by Refraction faintly tranſmitted to us; until the Sun having got about 18 Degrees below the Horizon, he no longer enlightens our *Atmoſphere*, and then all that Part thereof which is over us becomes

comes dark. After the ſame Manner, in the Morning, when the Sun comes within 18 Degrees of our Horizon, he again begins to enlighten the *Atmoſphere*, and ſo more and more by degrees, until he riſes and makes full Day. This ſmall Illumination of the *Atmoſphere*, and State of the Heavens between Day and Night, is called the *Twilight*, or the *Crepuſculum*.

Twilight, or the Crepuſculum.

The Duration of Twilight is different in different Climates, and in the ſame Place at different Times of the Year. The Beginning or Ending of Twilight being accurately given, we may from thence eaſily find the Height of the *Atmoſphere*, which is not always the ſame. The mean Height of the *Atmoſphere* is computed to be about 48 *Engliſh* Miles; but it is probable, the Air may expand it ſelf a great deal further, there being properly no other Limits to it, as we can conceive, but as it continually decreaſes in Denſity the farther remote it is from the Earth, in a certain Ratio; which at laſt, as to our Conception, muſt terminate.

By the *Crepuſculum* or Twilight to determin the true Height of our Atmoſphere; which is like a Husk, or Shell ſurrounding the Earth on every Side.

Let ADB be half of the Earth's enlighten'd Hemiſphere, D our Sub-Zenith, E the Sun when depreſs'd 17°. 27′ below the Horizon (that is, allowing 33′ for Refraction) DG our Horizontal Line, GE an Horizontal Line of Sun-ſet to them at E; biſect the Arch DE in G: So is there two right-angled Triangles, *viz.* DCG=GCE, whoſe Quantity is 8°. 43 ½: Let C be the Earth's Center, CF=CD=CE the Earth's Semi-diameter. 3984.58 *Engliſh* Miles; the Heighth of the Atmoſphere is FG: To find which in the right-angled plane Triangle CFG, I ſay, [See Plate I. Fig. 3.]

As S. Angle CGE	81° 16′ 30″	9.994945
To CE the ☉'s Semi-diameter	3984.58	3.600383
ſo Radius	90 00 00	10.000000
To CG	4031.7	3.605438
Earth's Semi-diameter Subtract CF	3984.58	
Remains FG	47.12	which is the

Heighth of the Atmoſphere in *Engliſh* Miles.

And if you would know, what Proportion its Heighth bears to the Earth's Semi-diameter, you will find it to be as 1 to 84.56. So the Heighth of the Atmoſphere to the Earth's Semi-diameter, thus 47.12) 3984.580 (84.56.

SECT.

SECT. II.

GEOGRAPHICAL DEFINITIONS: *Of the Situations of Places upon the Earth; of the different Situations of its Inhabitants; of Zones and Climates.*

THE Situation of Places upon the Earth are determined by their Latitude and Longitude.

1. The *Latitude* of any Place (upon the Earth) is its nearest Distance, either *North* or *South*, from the Equator; and if the Place be in the *Latitude.*

{Northern / Southern} Hemisphere, it is accordingly called {*North* / *South*} *Latitude*;

and is measured by an Arch of the Meridian passing thro' the Zenith of the said Place, and intercepted betwixt it and the Equator. And all Places that lie on the same Side, and at the same Distance from the Equator, are said to be in the same Parallel of Latitude: The Parallels of Latitude in *Geography* being the same with the Parallels of Declination in *Astronomy*.

From this Definition arise the following *Corollaries*.

(1.) *That no Place can have above* 90 *Degrees of Latitude, either* North *or* South.

(2.) *Those Places that lie under the Equinoctial (or thro' which the Equator passes) have no Latitude, it being from thence that the Calculation of Latitude is counted. And those Places that lie under the Poles have the greatest Latitude, those Points being at the greatest Distance from the Equator.*

(3.) *The Latitude of any Place is always equal to the Elevation of the Pole in the same Place, above the Horizon; and is therefore often expressed by the Pole's Height, or Elevation of the Pole: The Reason of which is, because from the Equator to the Pole, there is always the Distance of* 90 *Degrees, and from the Zenith to the Horizon the same Number of Degrees, each of these including the Distance from the Zenith to the Pole. That Distance therefore being taken away from both, will leave the Distance from the Zenith to the Equator, (which is the Latitude) equal to the Distance from the Pole to the Horizon.*

(4.) *The Elevation of the Equator in any Place, is always equal to the Complement of the Latitude of the same Place.*

(5.) *A*

(5.) *A Ship ſailing directly* {*towards* / *from*} *the Equator,* {*Leſſens* / *Augments*} *her Latitude, or* {*Depreſſes* / *Raiſes*} *the Pole, juſt ſo much as is her Diſtance ſailed.*

Difference of Latitude. 2. *Difference of Latitude* is the neareſt Diſtance betwixt any two Parallels of Latitude, ſhewing how far the one is to the Northward or Southward of the other; which can never exceed 180 Degrees. And when the two Places are in the ſame Hemiſphere (or on the ſame Side of the Equator) the leſſer Latitude ſubtracted from the greater, and when they are on different Sides of the Equator, the two Latitudes added, gives the Difference of Latitude.

Longitude 3. The *Longitude* of any Place (upon the Earth) is an Arch of the Equator, contained betwixt the Meridian of the given Place and ſome fixed or known Meridian: or, it is equal to the Angle formed by the two Meridians; which properly can never exceed 180 Degrees, tho' ſometimes the Longitude is counted Eaſterly quite round the Globe.

Since the Meridians are all moveable, and not one that can be fixed in the Heavens, (as the Equinoctial Circle is fixed, from whence the Latitudes of all Places are determined to be ſo much either *North* or *South*) the Longitudes of Places cannot ſo well be fixed from any one Meridian; but every Geographer is at his Liberty to make which he pleaſes his firſt Meridian, from whence to calculate the Longitudes of other Places. Hence it is, that the Geographers of different Nations, reckon their Longitudes from different Meridians, commonly chuſing the Meridian paſſing thro' the Metropolis of their own Country for their firſt: Thus, the *Engliſh* Geographers generally make the *Meridian* of *London* to be their firſt; the *French*, that of *Paris*; and the *Dutch*, that of *Amſterdam*, *&c.* And Mariners generally reckon their Longitude from the laſt known Land they ſaw. This arbitrary Way of reckoning the Longitude from different Places, makes it neceſſary, whenever we expreſs the Longitude of any Place, that the Place from whence it is counted be alſo expreſſed.

From the preceding Definitions ariſe the following *Corollaries*.

1. *If a Body ſhould ſteer directly* North, *or* South, *quite round the Globe he'll continually change his Latitude; and paſs thro' the two Poles of the World, without deviating the leaſt from the Meridian of the Place he de-*

parted

parted from; and consequently at his Return, will not differ in his Account of Time from the People residing in the said Place.

2. *If a Body should steer round the Globe, either due* East *or due* West, *he'll continually change his Longitude, but will go quite round without altering his Latitude; and if his Course should be due* East, *he'll gain a Day completely in his reckoning, or reckon one Day more than the Inhabitants of the Place from whence he departed: And if his Course had been* West, *he would have lost one Day, or reckoned one less.*

The Reason of which is evident: For, admitting our Traveller steers due *East* so many Miles in one Day, as to make his Difference of Longitude equivalent to a Quarter of an Hour of Time; it is evident, that the next Day the Sun will rise to him a Quarter of an Hour sooner, than to the Inhabitants of the Place from whence he departed: And so daily, in Proportion to the Rate he travels, which in going quite round will make up one natural Day. In like Manner, if he steers due *West* after the same Rate, he'll lengthen each Day a Quarter of an Hour, and consequently the Sun will rise to him so much later every Day; by which Means, in going quite round, he'll lose one Day complete in his reckoning. From whence it follows,

3. *If two Bodies should set out from the same Place, one steering* East, *and the other* West, *and so continue their Courses quite round, until they arrive at the Place from whence they set out, they'll differ two Days in their Reckoning at the Time of their Return.*

4. *If a Body should steer upon an oblique Course (or any where betwixt the Meridian and the* East *or* West *Points) he'll continally change both Latitude and Longitude, and that more or less, according to the Course he steers; and if he should go quite round the Globe, he'll differ in his Account of Time, as by the* 2d Corol.

5. *The People residing in the Eastermost of any two Places, will reckon their Time so much the sooner than those who live in the other Place, according to the Difference of Longitude betwixt the two Places, allowing* 1 *Hour for every* 15 *Degrees,* &c. *and the contrary.*

II. *Of Zones and Climates,* &c.

Zones Torrid, Temperate, and Frigid.

4. *Zones* are large Tracts of the Surface of the Earth, distinguished by the Tropics and Polar Circles; being five in Number, *viz.* one *Torrid*, two *Temperate*, and two *Frigid*.

The *Torrid* or *Burning Zone* is all the Space comprehended between the two Tropics; the Antients imagined this Tract of the

the Earth to be uninhabitable, becauſe of the exceſſive Heat, it being ſo near the Sun. All the Inhabitants of the *Torrid Zone* have the Sun in their Zenith, or exactly over their Heads, twice in every Year; excepting thoſe who live exactly under the two Tropics, where the Sun comes to their Zenith only once in a Year.

The two *Temperate Zones* lie on either Side of the Globe, between the Tropics and the Polar Circles.

The two *Frigid Zones* are thoſe Spaces upon the Globe that are included within the two Polar Circles.

The Dimenſions of each *Zone* in ſquare *Engliſh* Statute Miles (69,5 whereof make a Degree) are as follow, *viz.* Of the *Torrid Zone* 415474528457; of each *Temperate Zone* 270025710933; of each *Frigid Zone* 43209396510.

So that if the whole Earth be divided into 520 equal Parts, the *Torrid*, both *Temperate*, and both *Frigid Zones*, would bear nearly the following Proportions to one another.

The whole Surface of the *Earth* — — —	520
The *Torrid Zone* — — — — — —	207
Both *Temperate Zones* — — — — —	270
Both *Frigid Zones* — — — — —	43

To find the exact Proportion of the *Zones*, tho' the Quantity of the Earth's Surface is unknown.

The Diſtance of the Polar Circles from the Pole is 23°. 29′, whoſe Complement is 66°. 31′, its natural Sine is .917176, which deduct from 10.00000 gives .82824, and doubled, is .165648 for the exact Proportion of the two *Frigid Zones*.

The Diſtance of the Tropic from the Equator is 23°. 29′, its natural Sine is .398482, which deduct from the natural Sine of 66°. 31′ = .917176, remains .518694, and this doubled is 1.037388 for the Proportion of the two *Temperate Zones*.

And for the *Torrid Zone*, which is 23°. 29′ from the Equator on either Side, only double the natural Sine of 23°. 29′ = .398482, which will be — — — — .79696

The aforeſaid 2 *Temperate*	1.0373
The aforeſaid 2 *Frigid*	.1656
Proof In all, double *Radius*	2.0000

The Inhabitants of the Earth are alſo diſtinguiſhed by the Diverſity of their *Shadows*. Thoſe who live in the Torrid Zone, are called *Amphiſcians*; becauſe their Noon-Shadow is caſt different Ways, according as the Sun is to the Northward or Southward of the Zenith: But when the Sun is in their Zenith, they are called *Aſcians*.

Amphiſcians.

Aſcians.

The Inhabitants of the Temperate Zones, are called *Heteroſcians*, becauſe their Noon-Shadow is always caſt the ſame Way: But thoſe who live under the Tropics are called *Aſcians Heteroſcians*. Thoſe who live in the Frigid Zones are called *Periſcians*, becauſe ſometimes their Shadow is caſt round about them. *Heteroſcians.* *Aſcians Heteroſcians.* *Periſcians.*

Theſe hard Names are only *Greek* Words importing how the Sun caſts the Shadow of the ſeveral Inhabitants of the Earth; which would be a too trifling Diſtinction to be made here, was it not for the Sake of complying with Cuſtom.

The Inhabitants of the Earth, are alſo diſtinguiſhed into three Sorts, in reſpect to their relative Situation to one another; and theſe are called, the *Periæci*, *Antæci*, and *Antipodes*.

5. The *Periæci* are thoſe who live under oppoſite Points of the ſame Parallel of Latitude. They have their Seaſons of the Year at the ſame Time, and their Days and Nights always of the ſame Length with one another; but the one's *Noon* is the other's *Midnight*: And when the Sun is in the Equinoctial, he riſes with the one, when he ſets with the other. Thoſe who live under the Poles have no *Periæci*. *Periæci.*

6. The *Antæci* live under the ſame Meridian, and in the ſame Latitude, but on different Sides of the Equator; their Seaſons of the Year are contrary, and the Days of the one are equal to the Nights of the other: But the Hour of the Day and Night is the ſame with both; and when the Sun is in the Equinoctial, he riſes and ſets to both exactly at the ſame Time. Thoſe who live under the Equator have no *Antæci*. *Antæci.*

7. The *Antipodes* are thoſe who live diametrically oppoſite to one another, ſtanding, as it were, exactly Feet to Feet: Their Days and Nights, Summer and Winter, are at direct contrary Times. *Antipodes.*

The Surface of the Earth is by ſome diſtinguiſhed into *Climates*.

8 A *Climate* is a Tract of the Surface of the Earth included between two ſuch Parallels of Latitude, that the Length of the longeſt Day in the one, exceeds that in the other by half an Hour. *Climates.*

The whole Surface of the Earth, is conſidered as being divided into 60 Climates, *viz.* from the Equator to each of the Polar Circles 24, ariſing from the Difference of $\frac{1}{2}$ Hour in the Length of their longeſt Days; and from the Polar Circles to the Poles thenſelves are ſix, ariſing from the Difference of an entire Month; the Sun being ſeen in the the Firſt of theſe, a

whole Month without ſetting; in the Second, two; and in the Third, three Months, *&c.* Theſe Climates continually decreaſe in Breadth the farther they are from the Equator. How they are framed, *viz.* the Parallel of Latitude in which they end with the reſpective Breadth of each of them, is ſhewed in the following Table.

A TABLE *of the* CLIMATES.

CLIMATES *between the Equator and the Polar Circles.*

Climates.	Longeſt Day.	Latitude D.	Latitude M.	Breadth D.	Breadth M.	Climates.	Longeſt Day.	Latitude D.	Latitude M.	Breadth D.	Breadth M.
1	12½	8	25	8	25	13	18½	59	58	1	29
2	13	16	25	8	00	14	19	61	18	1	20
3	13½	23	50	7	25	15	19½	62	25	1	07
4	14	30	20	6	30	16	20	63	22	0	57
5	14½	36	28	6	08	17	20½	64	06	0	44
6	15	41	22	4	54	18	21	64	49	0	43
7	15½	45	29	4	07	19	21½	65	21	0	32
8	16	49	01	3	32	20	22	65	47	0	26
9	16½	51	58	2	57	21	22½	66	06	0	19
10	17	54	27	2	29	22	23	66	20	0	14
11	17½	56	37	2	10	23	23½	66	28	0	08
12	18	58	29	1	52	24	24	66	31	0	03

CLIMATES *between the Polar Circles and the Poles.*

Length of Days. Months.	Latitude. D.	Latitude. M.	Length of Days. Months.	Latitude. D.	Latitude. M.
1	67	21	4	78	30
2	69	48	5	84	05
3	73	37	6	90	00

III. *Of the Poetical Riſing and Setting of the Stars.*

Coſmical, Achronical and Heliacal Riſing and Setting.

The antient Poets make frequent mention of the Stars Riſing and Setting, either *Coſmically*, *Achronically*, or *Heliacally*; whence theſe Diſtinctions are called *Poetical*.

A Star is ſaid to *Riſe* or *Set Coſmically*, (*i. e.* in the Morning) when it riſes or ſets at Sun-riſing; and when it riſes or ſets at Sun-ſetting, it is ſaid to riſe or ſet *Achronically*, (*i. e.* in the Evening.) A Star *riſes Heliacally*, (*i. e.* out of the Sun's-beams) when firſt it becomes viſible, after it had been ſo near the Sun as to be hid by the Splendor of his Rays: And a Star is ſaid to *ſet Heliacally*, (*i. e.* into the Sun's-beams) when 'tis firſt immerſed, or hid by the Sun's Rays.

The *Fixed Stars*, and the three ſuperior Planets, *Mars*, *Jupiter*, and *Saturn*, riſe *Heliacally* in the Morning: But the *Moon* riſes *Heliacally* in the Evening; becauſe the Sun is ſwifter than the ſuperior Planets, and ſlower than the Moon.

The Arch of Viſion is the Arch of a Vertical Circle contained between the Horizon and the Center of the Sun after it is ſet, or before it riſeth, this altereth according to the ſeveral Magnitudes of the Stars, for the Greater the Star is, the Leſs is the Arch of Viſion, and the contrary.

The Arches of Viſion belonging to the Stars according to their ſeveral Magnitudes, are theſe.

	D.		D.
To the Firſt	12	*To the Planets.*	
Second	13	Venus	5
Third	14	Mercury	10
Fourth	15	Saturn	11
Fifth	16	Jupiter	9
Sixth	17	Mars	12½
Leaſt	18	Moon uncertain.	

Jupiter and *Venus* when brighteſt may be ſeen by Day.

A Star is ſaid to riſe Coſmically when it riſes with the Sun. So *Virg. Geo. L.* 1.

Candidus auratis aperit cum cornibus annum
Taurus, &c. i. e. When the Sun enters *Taurus*, and they both riſe at once.

A Star ſets Coſmically when it ſets at Sun-riſing. So *Virg. Geo. L.* 1.

Ante tibi Eoæ Atlantides abscondantur
Debita quam sulcis committas semina, quamq;
Invitæ properes anni spem credere terræ.

Harvest-Time is meant when the Sun being in *Scorpio*, the *Pleiades* set *Cosmically*.

A Star is said to rise *Achronically*, when it rises at Sun-setting.

Et Careo vobis scythicas detrusus in oras,
Quatuor autumnos Pleias Orta facit. Ovid.

The Sun being in *Scorpio*, the *Pleiades* rise *Achronically* and set *Cosmically*.

A Star is said to set *Achronically* when it sets with the Sun: So *Ovid. fast. L. 2.*

Quem modo cœlatum stellis Delphina videbas
Is fugiet visus nocte sequente tuos.

February the 3d, When the Sun being in *Aquary*, the *Delphin* sets *Achronically*.

Hence, the Sign, in which the Sun is, rises *Cosmically*, and sets *Achronically*, and the opposite Sign, at Night rises *Achronically*, and in the Morning sets *Cosmically*, according to this Distich.

Cosmice descendit Signum, quod Achronice surgit,
Chronice descendit Signum, quod Cosmice surgit.

The *Heliac* rising of a Star is when the Star appears in View after having been for some Time lost in the Sun's greater Light. So *Ovid. fast. L. 2.*

Jam levis obliqua subsedit Aquarius urna
Proximus æthereos excipe Pisce equos.

About the latter End of *February*.

Ante tibi Eoæ Atlantides abscondantur,
Gnosiaque ardentis decedat stella coronæ,
Debita quam sulcis committas semina &c. Virg. G. 1.

The Sun being in *Scorpio*, the *Pleiades* set *Cosmically*, and the *Corona Septentrionalis* arise *Heliacally*.

The *Heliac* Setting of a Star is when the Sun's greater Light obscures that Star.

Candidus auratis aperit cum cornibus annum
Taurus, & adverso cedens canis occidit astro.

IV. *Of the Surface of the Earth, considered as it is composed of Land and Water.*

The Earth consists naturally of two Parts, Land and Water; and therefore it is called the *Terraqueous Globe*. Each of these Elements

Elements are ſubdivided into various Forms and Parts, which accordingly are diſtinguiſhed by different Names.

I. *Of the Land.*

The Land is diſtinguiſhed into *Continents*, *Iſlands*, *Peninſula's*, *Iſthmus's*, *Promontories*, *Mountains*, or *Coaſts*.

9. A *Continent* is a large Quantity of Land, in which many great Countries are joined together, without being ſeparated from each other by the Sea: Such are *Europe*, *Aſia*, *Africa*, and the vaſt Continent of *America*; which four are the principal Diviſions of the Earth. A *Continent* is ſometimes called the *Main Land*. *Continent.* *Main Land.*

10. An *Iſland* is a Country, or Portion of Land environed round with Water: Such are *Great Britain* and *Ireland*; *Sardinia*, *Sicily*, *&c.* in the Mediterranean Sea; the *Iſles* of *Wight*, *Angleſey*, *&c.* near *England*. Alſo a ſmall Part of dry Land in the midſt of a River, is called an *Iſland*. Sometimes a large Iſland, when compared to a leſſer, is called the Continent; as if we compare the *Iſle* of *Wight* to *England*, the latter may be properly called the Continent.

11. A *Peninſula* is a Part of Land almoſt environed with Water, ſave one narrow Neck adjoining it to the Continent; Or, which is almoſt an Iſland. Such *Denmark* joining to *Germany*; alſo *Africa* is properly a large *Peninſula* joining to *Aſia*. *Peninſula.*

12. And *Iſthmus* is a narrow Neck of Land joining a *Peninſula* to the Continent; as the *Iſthmus* of *Sues*, which joins *Africa* to *Aſia*; that of *Panama* joining North and South *America*, *&c.* *Iſthmus.*

13. A *Promontory* is a high Part of Land ſtretching out into the Sea; and is often called a *Cape*, or *Headland*: Such is the *Cape of Good-Hope*, in the South of *Africa*; *Cape-Finiſter* on the Weſt of *Spain*; alſo the *Lizard-Point*, and the *Land's-End*, are two Capes or Headlands on the Weſt of *England*. A *Mountain* is a high Part of Land in the Midſt of a Country, over-topping the adjacent Parts. *Promontory.* *Mountain.*

14. A *Coaſt* or *Shore* is that Part of Land, which borders upon the Sea, whether it be in Iſlands or a Continent: And that Part of the Land which is far diſtant from the Sea, is called the *Inland Country*. Theſe are the uſual Diſtinctions of the Land. *A Coaſt or Shore.* *Inland.*

The

The Water is diſtinguiſhed into *Oceans*, *Seas*, *Lakes*, *Gulfs*, *Streights*, and *Rivers*.

The Ocean or Main Sea. 15. The *Ocean* or *Main-Sea*, is a vaſt ſpreading Collection of Water, not divided or ſeparated by Land running between: Such is the *Atlantic* or *Weſtern Ocean*, between *Europe* and *America*; the *Pacific Ocean* or *South-Sea*, *&c.*

Note, Thoſe Parts of the Ocean, which border upon the Land, are called by various Names, according to thoſe of the adjacent Countries; as the *Britiſh Sea*; the *Iriſh Sea*; the *French* and *Spaniſh Sea*.

A Lake. 16. A *Lake* is a Collection of deep ſtanding Water, incloſed all round with Land, and not having any viſible and open Communication with the Sea; But when this Lake is very large, it is commonly called a Sea, as the *Caſpian Sea* in *Aſia*, *&c.*

A Gulf. 17. A *Gulf* is a Part of the Sea, almoſt encompaſſed with Land, or, that which runs up a great Way into the Land; as the *Gulf of Venice*, *&c.* But if it be very large, 'tis rather called an *Inland Sea*; as the *Baltic Sea*, the *Mediterranean Sea*, the *Red Sea*, or the *Arabian Gulf*, *&c.* And a ſmall Part of the Sea thus environed with Land, is uſually called a *Bay*. If it be but a very ſmall Part, or as it were a ſmall Arm of the Sea that runs but a few Miles between the Land, it is called a *Creek* or *Haven*.

Creek or Haven.

A Streight. 18. A *Streight* is a narrow Paſſage lying between two Shores, whereby two Seas are joined together; as the *Streights of Dover*, between the *Britiſh* Channel, and the *German* Sea; the *Streights of Gibraltar*, between the *Atlantic* and the *Mediterranean* Sea. The *Mediterranean* it ſelf is alſo ſometimes called the *Streights*.

Theſe are all the neceſſary Terms commonly uſed in *Geography*. The Names of the ſeveral Countries, Seas, and all the principal Diviſions of the Earth, the Reader will find expreſſed upon the Terreſtrial Globes. To give a tolerable Account of the Produce of each Country, the Genius of the People, their Political Inſtitutions, *&c.* is properly a particular Subject of it ſelf; and quite foreign to our Deſign, and therefore refer to GORDON's *Geography*, or MOLL's, for further Information therein. We ſhall next proceed to the Uſe of the Globes; but firſt it may not be amiſs to give a ſhort *Review* of their Appurtenances.

Thoſe Circles of the Sphere that are *fixed* are (as has been already ſaid) drawn upon the *Globes* themſelves; thoſe that are *moveable*, are ſupplied by the *Braſs Meridian*, the *Wooden Horizon* and the *Quadrant of Altitude*.

Braſs Meridian. 1. That Side of the *Brazen Meridian*, which is divided into Degrees, repreſents the *true Meridian*

this Side is commonly turned towards the East, and 'tis usual to place the Globe so before you, that the North be to the Right-Hand, and the South to the Left. The Meridian is divided into 4 Quadrants, each being 90 Degrees, two of which are numbred from that Part of the Equinoctial, which is above the Horizon, towards each of the Poles; the other two Quadrants are numbred from the Poles towards the Equator. The Reason why two Quadrants of the Meridian are numbred from the Equator, and the other two from the Poles, is because the Former of these two serve to shew the Distance of any Point on the Globe from the Equator, and the other to elevate the Globe to the Latitude of the Place.

Wooden Horizon.

2. The upper Side of the Wooden Frame, called the Wooden Horizon, represents the true Horizon; the Circles drawn upon this Plane have been already described; we may observe, that the first Point of ♈ is the *East*, and the Opposite, being the first Point of ♎ is the *West*, the Meridian passing thro' the *North* and *South* Points.

Quadrant of Altitude.

3. The *Quadrant of Altitude* is a flexible Plate of thin Brass, having a Nut or Screw at one End, to be fastned to the Meridian of either Globe, as Occasion requires. The Edge of this Quadrant, which has the Graduations upon it, called the *Fiducial Edge*, is that which is always meant, whenever we make mention of the *Quadrant of Altitude*.

Hour-Circle.

4. The *Horary* or *Hour-Circle* is divided into twice twelve Hours; the two XII's coinciding with the Meridian: The uppermost XII is that at *Noon*, and the nethermost towards the Horizon is XII at *Night*. The Hours on the *East* Side of the Meridian are the *Morning Hours*, and those on the *West* Side the *Hours after Noon*. The Axis of the Globe carries round the *Hand* or *Index* which points the Hour, and it stands in the Center of the Hour-Circle.

The Things above described are common to both Globes; but there are some others which are peculiar, or proper to one Sort of Globe. The two *Colures*, and the *Circles* of *Latitude*, from the Ecliptic, belong only to the *Celestial Globe*; also the Ecliptic it self does properly belong only to this Globe, tho' it is always drawn on the Terrestrial, for the Sake of those that might not have the other Globe by them. The Equinoctial on the Celestial Globe is always numbred into 360 Degrees, beginning at the Equinoctial Point ♈; but on the Terrestrial, it is arbitrary where these Numbers commence, according to the Meridian at what Place you intend for your first; and the Degrees may be counted either quite round to 360. or both Ways, till they meet in the opposite Part of the Meridian at 180.

SECT.

SECT. III.

The *USE* of the *GLOBES*.

General Observations concerning the *Great Circles* on the *Artificial Globes*.

On the *Horizon* ſeek the
- Sun's Place.
- Day of the Month.
- Amplitude.
- Azimuth.
- Point of the Compaſs.
- Riſing or ſetting of the Stars.
- Diſtinction between Day and Night.
- Degrees for Hours in an Horizontal Dial.

On the *Meridian* ſeek the
- Sun or Stars Declination
- Meridian Altitude.
- Meridian Depreſſion.
- Latitude of a Place.
- Diſtance from the Pole
- Zenith and Nadir Point
- Diſtinction between Forenoon and Afternoon.

On the *Equinoctial* ſeek the
- Right Aſcenſion.
- Oblique Aſcenſion.
- Oblique Deſcenſion.
- Aſcenſional Difference.
- Longitude of Places.
- Semi-diurnal, Semi-nocturnal Arches.
- Planetary Hour.
- Diſtinction betwixt *North* and *South* Latitude of Places.
- Moſt exact and equal Meaſure of Time.

On the *Ecliptic* ſeek the
- Sun's Place or Longitude
- Apparent and Annual Motion.
- Stars Longitude.
- Poetical Riſing and Setting.
- Cuſps of all the Houſes
- Increaſe & Decreaſe of Days.
- Culminating Degree.
- Eclipſes of Sun & Moon
- Diſtinction of *North* and *South* Latitude of the Stars.

On the Equinoctial Colure seek the
- Spring.
- Autumn.
- Equality of Day and Night.
- Distinction of *North* and *South* Decliners.
- Things in Trigonotry and Dialling.

On the *Solstitial Colure* seek the
- Summer.
- Winter.
- Greateſt Declination *North* and *South*.
- Longeſt and Shorteſt Days.

On the Zodiac seek the
- Stars Altitude at any Time.
- Stars Latitude.
- Diſtance of Places or Stars.
- Almicantar.
- Degrees of declining Dials.

On the *Hour Index* ſeek the
- Hour. Alſo
- Sun's Riſing. Setting.
- Length of Day. Night.
- Twilight Beginning. Ending.
- Babilonic, Italic, Jewiſh, Aſtronomic Hour.

Geographical PROBLEMS.

Solv'd by the

GLOBES.

PROBLEM. I.

To try the Globes whether they are well made or not.

SEE that the Papers unite without lapping over, and that the Parts of one and the ſame Circle neatly meet, without any apparent Diſtance or Deviation; that the Equator always

cut the Horizon in the *East* and *West* Points, and in Degrees exactly 180 aſunder: Mind alſo, that 15 Degrees paſs thro' the Meridian as the Index changes Hours: That they be well illuminated and glazed, the Images of the Conſtellations correſpond in Figure to what they ſhould repreſent: That they be corrected from the beſt and neweſt Diſcoveries in *Aſtronomy* and *Geography*, eſpecially ſuch Obſervations in the Heavens as agree with Itineraries well examin'd on Earth.

Mind that the Globe hang evenly between the Meridian and Horizon not inclining more to one Side than the other, and not too far aſunder, alſo when the Pole is in the Zenith, ſee the Equinoctial be neither above nor under the Horizon in any Point. See alſo, that Half the Meridian be above and Half under the Horizon, ſo will the Degrees at the *North* and *South* Points of the Horizon always make 90°. and laſt of all: Let the Horizon be made ſtrong and ſubſtantial.

In uſing them.

Keep the *East* Side of the Horizon next, and the graduated Side of the Meridian before your Eyes, for the true Meridian is the *Eaſtern* graduated Face, and the upper Face of the Horizon is alſo the true Horizon, both which on the *Artificial Globe* have for Strength and Service ſome Thickneſs; yet in the *Natural Globe* they are *Great Circles*, without either Breadth or Depth.

Prob. II. *To find the Latitude and Longitude of any given Place upon the Globe; and on the contrary, the Latitude and Longitude being given, to find the Place.*

1. Turn the Globe round its Axis, till the given Place be exactly under the (Eaſtern Side of the Braſs) Meridian; then that Degree upon the Meridian, which is directly over it, is the *Latitude*: Which is accordingly North or South, as it lies in the Northern or Southern Hemiſphere. The Globe remaining in the ſame Poſition.

That Degree upon the Equator which is cut by the Brazen Meridian, is the *Longitude* required, from the firſt Meridian upon the Globe. If the Longitude is counted both Ways from the firſt Meridian upon the Globe, then we are to conſider, whether the given Place lies Eaſterly or Weſterly from the firſt Meridian, and the Longitude muſt be expreſſed accordingly.

The

The *Latitudes* of the following Places; and upon a Globe where the Longitude is reckoned both Ways from the Meridian of *London*, their *Longitudes* alſo will be found as follow.

	Latitude. Deg.	*Longitude.* Deg.
Rome —— ——	41¾ North.	13 Eaſt.
Paris —— ——	48¾ N.	2¼ E.
Mexico —— ——	20 N.	102 W.
Cape-Horn —— ——	58 S.	80 W.

2. *The Latitude and Longitude being given, to find the Place.*

Seek for the given Longitude in the Equator, and bring that Point to the Meridian; then count from the Equator on the Meridian, the Degree of Latitude given, towards the Arctic or Antactic Pole, according as the Latitude is Northerly or Southerly; and under that Degree of Latitude lies the *Place* required.

PROB. III. *Any Place being given, to find all thoſe Places that are in the ſame Latitude with the ſaid Place.*

The Latitude of the given Place being marked upon the Meridian, turn the Globe round its Axis, and all thoſe Places that paſs under the ſaid Mark, are in the ſame Latitude with the given Place, and have their Days and Nights of equal Lengths. And when any Place is brought to the Meridian, all the Inhabitants, that lie under the upper Semi-circle of it, have their Noon or Mid-day at the ſame Point of abſolute Time exactly.

PROB. IV. *To find the Diſtance between any two given Places upon the Globe, and to find all thoſe Places upon the Globe that are at the ſame Diſtance from a given Place.*

Lay the Quadrant of Altitude over both the Places, and the Number of Degrees intercepted between them being reduced into Miles, will be the Diſtance required: Or, you may take

the Diſtance betwixt the two Places with a Pair of Compaſſes, and applying that Extent to the Equator, you'll have the Degrees of Diſtance as before. *Note*, A *Geographical Mile* is the 60th Part of a Degree; wherefore if you multiply the Number of Degrees by 60, the Product will be the Number of Geographical Miles of Diſtance ſought; but to reduce the ſame into *Engliſh* Miles, you muſt multiply by 70, becauſe about 70 *Engliſh* Miles make a Degree of a great Circle upon the Superficies of the Earth.

Thus, the Diſtance betwixt *London* and *Rome* will be found to be about 13 Degrees, which is 780 Geographical Miles.

If you rectify the Globe for the Latitude and Zenith of any given Place, and bring the ſaid Place to the Meridian; then turning the Quadrant of Altitude about, all thoſe Places that are cut by the ſame Point of it, are at the ſame Diſtance from the given Place.

PROB. V. *To find the Angle of Poſition of Places; or, the Angle formed by the Meridian of one Place, and a great Circle paſſing through both the Places.*

Having rectified the Globe for the Latitude and Zenith of one of the given Places, bring the ſaid Place to the Meridian, then turn the Quadrant of Altitude about until the Fiducial Edge thereof cuts the other Place, and the Number of Degrees upon the Horizon contained between the ſaid Edge and the Meridian, will be the Angle of Poſition ſought.

Thus the *Angle* of *Poſition* at the *Lizard*, between the Meridian of the *Lizard* and the *Great Circle* paſſing from thence to *Barbadoes*, is 69 Degrees South-Weſterly; but the *Angle* of *Poſition* between the ſame Places at *Barbadoes*, is but 38 Degrees North-Eaſterly.

SCHOLIUM.

The *Angle* of *Poſition* between two Places is a different Thing from what is meant by the Bearings of Places; the *Bearings* of two Places is determined by a Sort of *Spiral-Line* called a *Rhumb-Line*, paſſing between them in ſuch a Manner, as to make the ſame or equal Angles with all the Meridians through which it paſſeth: But the *Angle* of *Poſition* is the very ſame Thing with what we call the *Azimuth* in *Aſtronomy*; both being formed by the Meridian and a *Great Circle* paſſing thro' the *Zenith* of a given Place, and a given Point, either in the Heavens, then called

called the *Azimuth*, or upon the Earth, then called the *Angle* of *Poſition*.

From hence may be ſhewn the Error of that *Geographical Paradox*, *viz.* If a Place *A* bears from another *B* due *Weſt*, *B* ſhall not bear from *A* due *Eaſt*. I find this Paradox vindicated by an Author, who at the ſame Time gives us a true Definition of a *Rhumb-Line*: But his Arguments are *Un-geometrical*; for if it be admitted that the *Eaſt* and *Weſt* Lines make the ſame Angles with all the Meridians, through which they paſs, it will follow that theſe Lines are the Parallels of Latitude. For the Path deſcribed in Travelling from *Eaſt* to *Weſt*, is the Continuation of the Surface of a *Cone*, whoſe Sides are the *Radii* of the Sphere, and *Baſe* the Parallel of Latitude of the Traveller: And it is evident, that all the Meridians cut the ſaid Surface at Right (and therefore at equal) Angles; whence it follows, that the *Rhumbs* of *Eaſt* and *Weſt* are the Parallels of Latitude; though the Caſe may ſeem different, when we draw inclining Lines (like Meridians) upon Paper, without carrying our Ideas any further.

PROB. VI. *To find the* Antæci, Periæci, *and* Antipodes *to any given Place.*

Bring the given Place to the Meridian, and having found its Latitude, count the ſame Number of Degrees on the Meridian from the Equator towards the contrary Pole, and that will give the Place of the *Antæci*. The Globe being ſtill in the ſame Poſition, ſet the Hour-Index to XII at Noon, then turn the Globe about till the Index points to the lower XII; the Place which then lies under the Meridian, having the ſame Latitude with the given Place, is the *Periæci* required. As the Globe now ſtands, the *Antipodes* of the given Place are under the ſame Point of the Meridian, that its *Antæci* ſtood before: Or, if you reckon 180 Degrees upon the Meridian from the given Place, that Point will be the *Antipodes*.

Let the given Place be *London* in the Latitude of 51½ Degrees *North*; that Place which lies under the ſame Meridian, and in the Latitude of 51½ Degrees *South*, is the *Antæci*: That which is in the ſame Parallel with *London*, and 180 Degrees of *Longitude* from it, is the *Periæci*; and the *Antipodes* is that Place whoſe *Longitude* from *London* is 180 Degrees, and *Latitude* 51½ Degrees *South*.

PROB.

PROB. VII. *The Hour of the Day at one Place, being given; to find the correſpondent Hour (or what o'Clock it is at that Time) in any other Place.*

The Difference of Time betwixt two Places is the ſame with their Difference of *Longitude*; wherefore having found their Difference of *Longitude*, reduce it into Time, (by allowing one Hour for every 15 Degrees, *&c.*) and if the Place where the Hour is required lies {Eaſterly, / Weſterly,} from the Place where the Hour is given, {Add / Subtract} the Difference of *Longitude* reduced into Time {to / from} the Hour given; and the Sum or Remainder will accordingly be the Hour required. Or,

Having brought the Place at which the Hour is given to the Meridian, ſet the Hour-Index to the given Hour; then turn the Globe about until the Place where the Hour is required comes to the Meridian, and the Index will point out the Hour at the ſaid Place.

Thus, when it is *Noon* at *London*, it is

		H.	M.	
At	*Rome*	0	52	P. M.
	Conſtantinople	2	07	P. M.
	Vera-Cruz	5	30	A. M.
	Pequin in *China*	7	50	P. M.

PROB. VIII. *The Day of the Month being given; to find thoſe Places on the Globe where the Sun will be Vertical, or in the Zenith, that Day.*

Having found the Sun's Place in the Ecliptic, bring the ſame to the Meridian, and note the Degree over it; then turning the Globe round, all Places that paſs under that Degree will have the Sun Vertical that Day.

PRO

PROB. IX. *A Place being given in the* Torrid Zone, *to find thoſe two Days in which the Sun ſhall be Vertical to the ſame.*

Bring the given Place to the Meridian, and mark what Degree of Latitude is exactly over it; then turning the Globe about thoſe two Points of the Ecliptic, which paſs exactly under the ſaid Mark, give the Sun's Place at the Times required; look upon the Wooden-Horizon for thoſe two Points of the Ecliptic, and right againſt them are the Days required.

PROB. X. *To find where the Sun is Vertical at any given Time aſſigned; or, the Day of the Month and the Hour at any Place (ſuppoſe* London*) being given, to find in what Place the Sun is Vertical at that very Time.*

Having found the Sun's Declination, and brought the firſt Place (*London*) to the Meridian, ſet the Index to the given Hour, then turn the Globe about until the Index points to 12 at Noon; which being done, that Place upon the Globe which ſtands under the Point of the Sun's Declination upon the Meridian, has the Sun that Moment in the Zenith.

PROB. XI. *The Day, and the Hour of the Day at one Place, being given; to find all thoſe Places upon the Earth, where the Sun is then Riſing, Setting, Culminating, (or on the Meridian;) alſo where it is Day-Light, Twilight, Dark-Night, Mid-night; where the Twilight then begins, and where it ends: The Height of the Sun in any Part of the illuminated Hemiſphere; alſo his Depreſſion in the obſcure Hemiſphere.*

Having found the Place where the Sun is Vertical at the given Hour, rectify the Globe for the Latitude, and bring the ſaid Place to the Meridian.

Then

Then all thoſe Places that are in the Weſtern Semicircle of the Horizon, have the Sun riſing at that Time.

Thoſe in the Eaſtern Semicircle have it ſetting.

To thoſe who live under the upper Semicircle of the Meridian, it is 12 o'Clock at Noon. And,

Thoſe who live under the lower Semicircle of the Meridian have it Midnight.

All thoſe Places that are above the Horizon, have the Sun above them, juſt ſo much as the Places themſelves are diſtant from the Horizon; which Heighth may be known by fixing the Quadrant of Altitude in the Zenith, and laying it over any particular Place.

In all thoſe Places that are 18 Degrees below the Weſtern Side of the Horizon, the Twilight is juſt beginning in the Morning, or the Day breaks. And in all thoſe Places that are 18 Degrees below the Eaſtern Side of the Horizon, the Twilight is ending, and the total Darkneſs beginning.

The Twilight is in all thoſe Places whoſe Depreſſion below the Horizon does not exceed 18 Degrees. And,

All thoſe Places that are lower than 18 Degrees have dark Night.

The Depreſſion of any Place below the Horizon is equal to the Altitude of its *Antipodes*, which may be eaſily found by the *Quadrant of Altitude*. Or,

The ſame another Way.

At one Poſition *of the* Globe *to demonſtrate where 'tis Day, where Night, where the Sun is in their* Zenith, *what is its Declination, where it is Morning, Noon, Evening, how and where Night comes on, and Day break appears, where 'tis continual Day or continual Night, the Hour of the Day,* &c.

1. Take the *Terreſtrial Ball* out of the *Horizon*, and faſten a Thread to the *Latitude* of the Place. 2. Hang it up ſafe in the open Sun-ſhine. 3. Turn its Meridian due *North* and *South*, by the Help of the Compaſs, or rather a true Meridian-Line. Bring the Place to the Meridian, conſequently to the Zenith, and the *North* Pole pointing to the *North* Pole in the Heaven, ſo will the *Terreſtrial Globe* correſpond in all Reſpects to the Earth it ſelf.

5. The

5. Then with Pleaſure may one behold the little *Globe*, like the big *Earth*, having one Half light, the other dark, and conſequently where Day is, and where it is Night.

6. If a *Spheric Gnomon* be ſet in the Middle of the enlightned Hemiſphere, it will project no Shadow, which demonſtrates the Sun to be in the Zenith of that Place, which Place moved to the Meridian, gives the Latitude of that Place, and the preſent Declination of the Sun.

☞ A *Spheric Gnomon* may be a Pin perpendicularly erected on a ſmall Baſis of Wood or Cork, with an hollow Bottom to ſtand on the *Globe*, not unlike a Coffee-cup inverted.

7. All Places then under the Meridian have their Noon or Mid-night according as they are Light or Dark: Thoſe on the *Weſt* have their Morning, for with them the Sun is *Eaſt*: Thoſe on the *Eaſt* have their Evening, for with them the Sun is *Weſt*.

8. Bring then your Place to the Meridian, and all thoſe Places lying betwixt the enlightned and dark Half have the Sun in their Horizon Riſing, if Weſtward off the Meridian; but Setting, if Eaſtward.

9. Keeping the *Globe* ſteady, one may ſee on the *Eaſt*, what Places grow dark, there Night comes on; and on the *Weſt*, what Places grow light, there Day approaches.

10. Obſerve in what Degree of *Longitude* the Light is parted from the Dark Half; the Difference of *Longitude* betwixt it and the *Longitude* of any Place reduced into Time, ſhows how long it is to or ſince Sun-riſe, or Sun-ſet, according to the Situation of the Place.

11. As many Degrees as the Sun-ſhine reaches beyond either *North* or *South-Pole*, ſo many Degrees is his Declination *North* or *South*.

12. In all Places about the Pole where it is Sun-ſhine, while the *Globe* is turned round, there is conſtant Day, till the Sun decreaſe in Declination.

13. In the oppoſite Pole where 'tis dark, while the *Globe* is turned round, there will be continual Night, till the Sun decreaſe in Declination.

PROB. XII. *To find the Length of the longeſt and ſhorteſt Day and Night in any given Place, not exceeding* $66\frac{1}{2}$ *Degrees of Latitude.*

Note. The longeſt Day at all Places on the { *North* / *South* } Side of the Equator, is when the Sun is in the firſt Point of { *Cancer*: / *Capricorn*: } Wherefore having rectified the Globe

for the Latitude, find the Time of Sun-riſing and Setting, and thence the Length of the Day and Night accordding to the Place of the Sun: or having rectified the Globe for the Latitude, bring the ſolſtitial Point of that Hemiſphere to the *Eaſt* Part of the Horizon, and ſet the Index to 12 at Noon; then turning the Globe about till the ſaid Solſtitial Point touches the Weſtern Side of the Horizon; the Number of Hours from Noon to the Place, where the Index points (being counted according to the Motion of the Index) is the Length of the Longeſt Day; the Complement whereof to 24 Hours, is the Length of the ſhorteſt Night, and the Reverſe gives the ſhorteſt Day and the longeſt Night.

	Longeſt Day.	*Short. Night.*
	Deg. *Hours.*	*Hours.*
Thus in Lat.	45 — 15½	8½
	51½ — 16½	7½
	60 — 18½	5½

If from the Length of the longeſt Day, we ſubtract 12 Hours, the Number of Half-Hours remaining will be the *Climate*: Thus, that Place where the longeſt Day is 16½ Hours, lies in the 9th *Climate*. And by the Reverſe, having the *Climate*, we have thereby the Length of the longeſt Day.

PROB. XIII. *A Place being given in one of the* Frigid Zones *(ſuppoſe the* Northern*) to find what Number of Days (of* 24 *Hours each) the Sun doth conſtantly ſhine upon the ſame, how long he is abſent, and alſo the firſt and laſt Day of his Appearance.*

Having rectified the Globe according to the Latitude, turn it about until ſome Point in the firſt Quadrant of the Ecliptic (becauſe the Latitude is *North*) interſect the Meridian in the *North* Point of the Horizon; and right againſt that Point of the Ecliptic on the Horizon, ſtands the Day of the Month when the longeſt Day begins.

And if the Globe be turned about till ſome Point in the ſecond Quadrant of the Ecliptic cuts the Meridian in the ſame Point of the Horizon, it will ſhew the Sun's Place when the longeſt Day ends; whence the Day of the Month may be found as before. Then the Number of Natural Days contain'd between the Times the longeſt Day begins and ends, is the Length of the longeſt Day required.

Again

Again turn the Globe about, until ſome Point in the third Quadrant of the Ecliptic cuts the Meridian in the *South* Part of the Horizon; that Point of the Ecliptic will give the Time when the longeſt Night begins. *Laſtly*, Turn the Globe about until ſome Point in the fourth Quadrant of the Ecliptic cuts the Meridian in the *South* Point of the Horizon; and that Point of the Ecliptic will be the Place of the Sun, when the longeſt Night ends,

Or, the Time when the longeſt Day or Night begins, being known, their End may be found by counting the Number of Days from that Time to the ſucceeding Solſtice; then counting the ſame Number of Days from the Solſtitial Day, will give the Time when it ends.

Or, if we bring the Solſtitial Point ♋ to the *North* Part of the Meridian, then keep the Globe in that Poſition; the Place where the Ecliptic cuts the *North-Eaſtern* and *North Weſtern* Parts of the Horizon, will be the Sun's Place when the longeſt Day begins and ends; and where it cuts the *South-Weſtern*, and *South-Eaſtern* Parts of the Horizon, will be the Place of the Sun when the longeſt Night begins and ends.

Thus at the *North-Cape* on the Coaſt of *Lapland*, in the Latitude of 71½ Degrees, the longeſt Day begins about the 4th of *May*, and ends the 19th of *July* following, during the Space of 77 Days; after which, the Sun riſes and ſets till the 4th of *November*, when he but firſt touches the Horizon in the Southerneſt Point of it, and then continues below it till the 16th of *January*, when he'll juſt appear to riſe in the Meridian after he had been hid below the Horizon, for the Space of 73 *Natural* Days, which is the Length of the longeſt Night. So that the longeſt Day is longer than the longeſt Night by the Space of 4 Days, which Inequality ariſes from the Eccentricity of the Earth's Orbit.

After the ſame Manner may theſe Things be eaſily found for any Place either within the *Arctic* or *Antarctic Circle*.

A TABLE *shewing the longeſt Day in all Places, from the* Equinoctial *to the* Poles *of the World*, viz.

Pol. Height.	Longeſt Day. H.	M.	Pol. Height.	Longeſt Day. H.	M.	Pol. Height.	Longeſt Day, containing. Days.	H.	M.
0	12	0	47	15	42	68	42	1	16
6	12	20	48	15	52	69	54	16	25
12	12	42	49	16	0	70	64	13	46
16	12	58	50	16	10	71	74	00	00
20	13	12	51	16	20	72	82	6	36
24	13	26	52	16	30	73	89	4	58
27	13	42	53	16	42	74	96	17	00
30	13	56	54	16	54	75	104	01	04
32	14	6	55	17	08	76	110	07	27
34	14	16	56	17	22	77	116	14	22
35	14	22	57	17	36	78	122	17	06
36	14	28	58	17	52	79	127	9	55
37	14	34	59	18	10	80	134	4	58
38	14	38	60	18	30	81	139	1	36
39	14	44	61	18	54	82	145	6	43
40	14	52	62	19	20	83	152	2	06
41	14	58	63	19	50	84	156	3	03
42	15	4	64	20	24	85	161	5	23
43	15	12	65	21	10	86	166	11	23
44	15	18	66	22	18	87	171	21	47
45	15	26	66½	24	00	88	176	5	29
46	15	34	67	24	Days	89	181	21	58
						90	187	06	39

PROB. XIV. *To find the Time when total Darkneſs ceaſes, or when the Twilight continues from Sun-ſetting to Sun-riſing, in any given Place.*

Let the Place be in the Northern Hemiſphere; then if the Complement of the Latitude be greater than (the Depreſſion) 18 Degrees, ſubtract 18 Degrees from it, and the Remainder will

will be the Sun's Declination *North*, when total Darkneſs ceaſes. But if the Complement of the Latitude is leſs than 18 Degrees, their Difference will be the Suns Declination *South*, when the Twilight begins to continue all Night. If the Latitude is *South*, the only Difference will be, that the Sun's Declination will be on the contrary Side.

Thus at *London*, when the Sun's Declination *North* is greater than 20½ Degrees, there is no total Darkneſs, but conſtant Twilight, which happens from the 15th of *May* to the 7th of *July*, being near two Months. Under the *North Pole* the Twilight ceaſes, when the Sun's Declination is greater than 18 Degrees *South*; which is from the 2d of *November*, till the 18th of *January*: So that notwithſtanding the Sun is abſent in this Part of the World for half a Year together, yet total Darkneſs does not continue above 11 Weeks; and beſides, the *Moon* is above the Horizon once a Month for a whole Fortnight, throughout the Year.

PROB. XV. *The Day of the Month being given, to find thoſe Places of the* Frigid Zones, *where the Sun begins to ſhine conſtantly without ſetting; and alſo thoſe Places where he begins to be totally abſent.*

Bring the Sun's Place to the Meridian, and mark the Number of Degrees contained betwixt that Point and the Equator; then count the ſame Number of Degrees from the neareſt Pole (*viz.* the *North-Pole*, if the Sun's Declination is Northerly, otherwiſe the *South-Pole*) towards the Equator, and note that Point upon the Meridian; then turn the Globe about, and all the Places which paſs under the ſaid Point, are thoſe where the Sun begins to ſhine conſtantly, without ſetting on the given Day. If we lay the ſame Diſtance from the oppoſite Pole towards the Equator, and turn the Globe about, all the Places which paſs under that Point, will be thoſe where the longeſt Night begins.

Or, Otherwiſe.

1. Find the Sun's Declination for that Day. 2. Reckon the ſame Number of Degrees with the Declination from the Pole towards

towards the Equator on the Meridian. 3. All the Places paſſing under that Degree, while the Globe is turned round, are thoſe Places on which the Sun begins to ſhine or diſappear, with this Diſtinction.

When the Declination is *North* increaſing, the Sun begins to {Shine / Diſappear} in the {*North* / *South*} *Frigid Zone.*

But when the Declination is *South* increaſing, the Sun begins to {Shine / Diſappear} in the {*South* / *North*} *Frigid Zone.*

Let the Day given be in Spring *or* Autumn.

PROB. XVI. *In the* Frigid Zones *to find the Time of Sun-ſhine, and his Diſappearance; alſo the firſt and laſt Day of his Appearance, having a Place given.*

1. Find its Latitude. 2. Count how many Degrees its Latitude wants of 90°. or is diſtant from the Pole, which Number account the Sun's Declination both *North* and *South*, increaſing and decreaſing. 3. By this Declination find the Sun's Places, which will be four, as is evident, by obſerving what Degrees of the Ecliptic are cut by the Degree of Declination on the Meridian on both Sides of the Equator. 4. Againſt the ſaid four Places of the Sun in the Horizon, find the four Days and Months in all the Quarters. Then obſerve,

If the Place be in the *North Frigid Zone*, the Day in the {*Spring* / *Summer* / *Autumn* / *Winter*} Quarter is the {First / Laſt / First / Laſt} of the Sun's {Appearance: betwixt which the Sun never Sets. / Diſappearance: betwixt which the Sun never Riſes.}

But if the Place be in the *South Frigid Zone*, the Day in the {*Spring* / *Summer* / *Autumn* / *Winter*} Quarter is the {First / Laſt / First / Laſt} of the Sun's {Diſappearance: betwixt which the Sun never Riſes. / Appearance: betwixt which the Sun never Sets.}

In a *Table of Declination* may the Days be eaſily found and reckoned exactly.

PROB.

PROB. XVII. *Any Number of Days leſs than* 182, *to find the Latitude, wherein the Sun ſetteth not, during thoſe Days.*

1. Count from ♋ on the Ecliptic ſo many Degrees as half the Number of Days given, ſave one. 2. Bring that Point where the Count ends to the Meridian. 3. The Degree of the Meridian juſt over it deduct from 90, the Remainder is the Latitude *North*; if it were required in the *South* Latitude; do the like from ♑, &c. as before.

Aſtronomical PROBLEMS.

Solv'd by the

GLOBES.

PROBLEM I.

The Day of the Month being given; to find the Sun's Place in the Ecliptic, and his Declination.

TO *find the Sun's Place*: Look for the Day of the Month given in the Kalendar of Months upon the Horizon, and right againſt it we find that Sign and Degree of the Ecliptic which the Sun is in: The Sun's Place being thus found, look for the ſame in the Ecliptic Line which is drawn upon the Globe, and bring that Point to the Meridian; then that Degree of the Meridian which is directly over the Sun's Place is the *Declination* required. which is accordingly either *North* or *South*, as the Sun is in the Northern or Southern Signs. Thus

April

	Sun's Place.			Declination.		
		Deg.	Min.	Deg.	Min.	
April 12	♉	3	00	12	32	N.
July 20	♌	7	51	18	20	N.
October 15	♏	2	49	12	28	S.
January 9	♒	0	17	20	07	S.

PROB. II. *To rectify the Globes for the Latitude, Zenith, and the Sun's Place*

1. *For the Latitude*: If the Place be in the Northern Hemiſphere, raiſe the Arctic Pole above the Horizon; but for a *South* Latitude, raiſe the Antarctic; then move the Meridian up and down in the Notches, until the Degrees of the Latitude counted upon the Meridian below the Pole, cuts the Horizon and then the Globe is adjuſted to the Latitude.

2. *To rectify the Globe for the Zenith*: Having elevated the Globe according to the Latitude, count the Degrees thereof upon the Meridian from the Equator towards the elevated Pole, and that Point will be the Zenith or the Vertex of the Place: To that Point of the Meridian faſten the Quadrant of Altitude, ſo that the graduated Edge thereof may be joined to the ſaid Point.

3. Bring the Sun's Place in the Ecliptic to the Meridian, and then ſet the Hour-Index to XII at Noon, and the Globe will be rectified *to the Sun's Place.*

If there be a little Mariner's Compaſs, the Meridian of the Globe may be eaſily ſet to the Meridian of the Place.

PROB. III. *The Day of the Month being given, to ſhew, at one View, the Length of Day and Night in all Places upon the Earth at that Time; and to explain how the Viciſſitudes of Day and Night are really made by the Motion of the Earth round its Axis in* 24 *Hours, the Sun ſtanding ſtill.*

The Sun always illuminates one half of the Globe, or that Hemiſphere which is next towards him, while the other remains in Darkneſs: And if we elevate the Globe according to the Sun's Place in the Ecliptic, it is evident, that the Sun (being at an immenſe Diſtance from the Earth) illuminates all that Hemiſphere, which is above the Horizon; the Wooden Horizon

Horizon it ſelf will be the Circle terminating Light and Darkneſs; and all thoſe Places that are below it, are wholly deprived of the Solar Light.

The Globe ſtanding in this Poſition; thoſe Arches of the Parallels of Latitude which ſtand above the Horizon, are the *Diurnal Arches*, or the Length of the Day in all thoſe Latitudes at that Time of the Year; and the remaining Parts of thoſe Parallels, which are below the Horizon, are the *Nocturnal Arches*, or the Length of the Night in thoſe Places. The Length of the *Diurnal Arches* may be found, by counting how many Hours are contained between the two Meridians, cutting any Parallel of Latitude, in the Eaſtern or Weſtern Parts of the Horizon.

In all thoſe Places that are in the Weſtern Semicircle of the Horizon, the Sun appears Riſing: For, the Sun ſtanding ſtill in the Vertex, (or above the Braſs-Meridian) appears Eaſterly, and 90 Degrees diſtant from all thoſe Places that are in the Weſtern Semicircle of the Horizon; and therefore in thoſe Places he is then Riſing. Now if we pitch upon any particular Place upon the Globe, and bring it to the Meridian, and then bring the Hour-Index to the lower XII, which in this Caſe we'll ſuppoſe to be 12 at Noon, (becauſe otherwiſe the Numbers upon the Hour-Circle will not anſwer our Purpoſe;) and afterwards turn the Globe about, until the aforeſaid Place be brought to the Weſtern Side of the Horizon; the Index will then ſhew the Time of Sun-riſing in that Place. Then turning the Globe gradually about from *Weſt* to *Eaſt*, and minding the Hour-Index; we ſhall ſee the Progreſs made in the Day every Hour, in all Latitudes upon the Globe, by the Real Motion of the Earth round its Axis; until, by their continual Approach to the Braſs-Meridian (over which the Sun ſtands ſtill all the while) they at laſt have Noon-Day, and the Sun appears at the higheſt; and then by degrees, as they move Eaſterly, the Sun ſeems to decline Weſtward, until, as the Places ſucceſſively arrive in the Eaſtern Part of the Horizon, the Sun appears to ſet in the Weſtern; for the Places that are in the Horizon, are 90 Degrees diſtant from the Sun. We may obſerve, that all Places upon the Earth, that differ in Latitude, have their Days of different length, (except when the Sun is in the Equinoctial) being longer or ſhorter, in Proportion to what Part of the Parallels ſtand above the Horizon. Thoſe that are in the ſame Latitude have their Days of the ſame Length; but have them commence ſooner or later, according as the Places differ in Longitude.

PROB. IV. *To explain in general the Alteration of Seaſons, or Length of the Days and Nights, made in all Places of the World, by the Sun's (or the Earth's) annual Motion in the Ecliptic.*

It has been ſhewn in the laſt *Problem*, how to place the Globe in ſuch a Poſition, as to exhibit the Length of the *Diurnal* and *Nocturnal Arches*, in all Places of the Earth, at a particular Time: If the Hour-Circle be taken off, ſo that the Poles of the Globe may be brought to the Horizon; and the Globe be continually rectified, according as the Sun alters his Declination, (which may be known by bringing each Degree of the Ecliptic ſucceſſively to the Meridian) we ſee the gradual Increaſe or Decreaſe made in the Days in all Places of the World, according as a greater or leſſer Portion of the Parallels of Latitude ſtand above the Horizon. We ſhall illuſtrate this *Problem* by Examples taken at different Times of the Year.

1. Let the Sun be in the firſt Point of ♋, (which happens on the 10th of *June*) that Point being brought to the Meridian, will ſhew the Sun's Declination to be 23½ Degrees *North*; then the Globe muſt be rectified to the Latitude of 23½ Degrees; and for the better Illuſtration of the *Problem*, let the firſt Meridian upon the Globe be brought under the Braſs Meridian. The Globe being in this Poſition, we ſee at one View the Length of the Days in all Latitudes, by counting the Number of Hours contained between the two extreme Meridians, cutting any particular Parallel we pitch upon, in the Eaſtern and Weſtern Part of the Horizon. And we may obſerve that the lower Part of the Arctic Circle juſt touches the Horizon, and conſequently all the People who live in that Latitude have the Sun above their Horizon for the Space of 24 Hours, without ſetting; only when it is in the lower Part of the Meridian (which they would call 12 at Night) he juſt touches the Horizon.

To all thoſe who live between the Arctic Circle and the Pole, the Sun does not ſet, and its Heighth above the Horizon, when he is in the lower Part of the Meridian, is equal to their Diſtance from the Arctic Circle: For Example, Thoſe who live in the 80th Parallel have the Sun, when he is loweſt, at this Time 13½ Degrees high.

If we caſt our Eye Southward, towards the Equator, we ſhall find, that the Diurnal Arches, or the Length of the Days in the ſeveral Latitudes, gradually leſſen: The Diurnal Arch

f the Parallel of *London* at this Time is 16½ Hours; that of the quator (is always) 12 Hours; and ſo continually leſs, till we ome to the *Antarctic Circle*, the upper Part of which juſt touches he Horizon; and thoſe who live in this Latitude, have juſt ne ſight of the Sun, peeping as it were in the Horizon. nd all that Space between the *Antarctic Circle* and the *South* ole, lies in total Darkneſs.

If from this Poſition we gradually move the Meridian f the Globe, according to the progreſſive Alterations ade in the Sun's Declination, by his Motion in the Ecliptic; e ſhall find the Diurnal Arches of all thoſe Parallels, that e on the Northern Side of the Equator continually decreaſe; nd thoſe on the Southern Side continually increaſe, in the me Manner as the Days in thoſe Places ſhorten and lengthen. et us again obſerve the Globe, when the Sun has got with- 10 Degrees of the Equinoctial; now the lower Part of the oth Parallel of *North* Latitude juſt touches the Horizon, and l the Space betwixt this and the Pole, falls in the illumina- d Hemiſphere; but all thoſe Parallels that lie betwixt this nd the Arctic Circle, which before were wholly above the orizon, do now interſect it, and the Sun appears to them to ſe and ſet. From hence to the Equator, we ſhall find that e Days have gradually ſhortned; and from the Equator uthward, they have gradually lengthned, until we come to e 80th Parallel of *South* Latitude; the upper Part of which ſt touches the Horizon, and all Places betwixt this and the *uth* Pole are in total Darkneſs: But thoſe Parallels betwixt is and the Antarctic Circle, which before were wholly above e Horizon, are now partly above it; the Length of their ays being exactly equal to that of the Nights in the ſame titude in the contrary Hemiſphere. This alſo holds univer- lly, that the Length of the Day in one Latitude *North*, is ex- tly equal to the Length of the Night in the ſame Latitude *uth*; and *vice verſa*.

Let us again follow the Motion of the Sun, until he has got to the Equinoctial, and take a View of the Globe while it in this Poſition. Now all the Parallels of Latitude are cut to two equal Parts by the Horizon, and conſequently the ays and Nights are of equal Lengths, *viz.* 12 Hours each in l Places of the World; the Sun riſing and ſetting at Six Clock, excepting under the two *Poles*, which now lie exactly the Horizon: Here the Sun ſeems to ſtand ſtill in the ſame oint of the Heavens for ſome Time, until by Degrees, by s Motion in the Ecliptic, he aſcends higher to one, and diſ- ppears to the other, there being properly no Days and Nights

under the Poles; for there the Motion of the Earth round its Axis can't be observed.

If we follow the Motion of the Sun towards the Southern Tropic, we shall see the Diurnal Arches of the Northern Parallels continually decrease, and the Southern ones increase in the same Proportion, according to their respective Latitudes: The *North* Pole continually descending, and the *South* Pole ascending above the Horizon, until the Sun arrives into ♑, at which Time, all the Space within the Antarctic Circle is above the Horizon; while the Space between the Arctic Circle and its Neighbouring Pole, is in total Darkness. And we shall now find all other Circumstances quite reverse to what they were when the Sun was in ♋; the Nights now all over the World being of the same Length that the Days were of before.

We have now got to the Extremity of the Sun's Declination; and if we follow him thro' the other half of the Ecliptic, and rectify the Globe accordingly, we shall find the Seasons return in their Order, until at length we bring the Globe into its first Position.

PROB. V. *To shew by the Globe, at one View, the Length of the Days and Nights in any particular Place, at all Times of the Year.*

Because the Sun by his Motion in the Ecliptic, alters his Declination a small Matter every Day; if we suppose all the Torrid Zone to be filled up with a Spiral Line, having so many Turnings; or a Screw having so many Threads, as the Sun is Days in going from one Tropic to the other; and these Threads at the same Distance from one another in all Places, as the Sun alters his Declination in one Day in all those Places respectively. This Spiral Line or Screw will represent the apparent Paths described by the Sun round the Earth every Day; and by following the Thread from one Tropic to the other, and back again, we shall have the Path the Sun seems to describe round the Earth in a Year. But because the Inclinations of these Threads to one another are but small, we may suppose each Diurnal Path to be one of the Parallels of Latitude, drawn, or supposed to be drawn upon the Globe. Thus much being premised, we shall explain this *Problem*, by placing the Globe according to some of the most remarkable Positions of it; as before we did for the most remarkable Seasons of the Year.

In the preceding *Problem*, the Globe being rectified according the Sun's Declination, the upper Parts of the Parallels of titude, repreſented the *Diurnal Arches*, or the Length of the ays all over the World at that particular Time: Here we are rectify the Globe according to the Latitude of the Place, d then the upper Parts of the Parallels of Declination are e Diurnal Arches; and the Length of the Days at all Times the Year, may be here determined, by finding the Number Hours contained between the two extreme Meridians, hich cut any Parallel of Declination, in the Eaſtern and eſtern Points of the Horizon; after the ſame Manner as fore we found the Length of the Day in the ſeveral Latides at a particular Time of the Year.

1. Let the Place propoſed be under the Equinoctial, and let e Globe be accordingly rectified for 00 Degrees of Latitude, hich is called a direct Poſition of the Sphere. Here all the rallels of Latitude, which in this Caſe we'll call the Paralls of Declination, are cut by the Horizon into two equal rts; and conſequently thoſe who live under the Equinoctial ve the Days and Nights of the ſame Length at all Times of e Year; alſo in this Part of the Earth, all the *Stars* riſe and , and their Continuance above the Horizon, is equal to eir Stay below it, *viz.* 12 Hours.

If from this Poſition we gradually move the Globe accorng to the ſeveral Alterations of Latitudes, which we will ppoſe to be Northerly; the Lengths of the Diurnal Arches ll continually increaſe, until we come to a Parallel of Denation, as far diſtant from the Equinoctial, as the Place it f is from the Pole. This Parallel will juſt touch the Horin, and all the Heavenly Bodies that are betwixt it and the le never deſcend below the Horizon. In the mean Time, ile we are moving the Globe, the Lengths of the Diurnal ches of the Southern Parallels of Declination, continually miniſh in the ſame Proportion that the Northern ones inaſed; until we come to that Parallel of Declination which ſo far diſtant from the Equinoctial Southerly, as the Place ſelf is from the *North* Pole. The upper Part of this *Parallel* t touches the Horizon, and all the Stars that are betwixt it d the *South* Pole, never appear above the Horizon. All the ſcturnal Arches of the Southern Parallels of Declination, are actly of the ſame Length with the Diurnal Arches of the reſpondent Parallels of *North* Declination.

2. Let us take a View of the Globe, when it is rectified for Latitude of *London*, or 51½ Degrees *North*. When the Sun in the Tropic of ♋, the Day is about 16½ Hours; as he reſes from this Tropic, the Days proportionably ſhorten, until

til he arrives into ♑, and then the Days are at the shortest being now of the same Length with the Night when the Sun was in ♋, *viz.* 7½ Hours. The lower Part of that Parallel of Declination, which is 38½ Degrees from the Equinoctial Northerly, just touches the Horizon; and all the Stars that are betwixt this Parallel and the *North* Pole, never set to us at *London*. In like Manner the upper Part of the Southern Parallel of 38½ Degrees just touches the Horizon, and all the Stars that lie betwixt this Parallel and the *South* Pole are never visible in this Latitude.

Again, let us rectify the Globe for the Latitude of the *Arctic Circle*, we shall then find, that when the Sun is in ♋, he touches the Horizon on that Day, without setting, being 24 Hours complete above the Horizon; and when he is in *Capricorn*, he once appears in the Horizon, but does not rise for the Space of 24 Hours: When he is in any other Point of the Ecliptic the Days are longer or shorter, according to his Distance from the Tropics. All the Stars that lie between the Tropic of *Cancer*, and the *North* Pole, never set in this Latitude; and those that are between the Tropic of *Capricorn* and the *South* Pole, are always hid below the Horizon.

If we elevate the Globe still higher, the Circle of *perpetual Apparition* will be nearer the Equator, as will that of *perpetual Occultation* on the other Side. For Example, Let us rectify the Globe for the Latitude of 80 Degrees *North*; when the Sun's Declination is 10 Degrees *North*, he begins to turn above the Horizon without setting, and all the while he is making his Progress from this Point to the Tropic of ♋, and back again, he never sets. After the same Manner, when his Declination is 10 Degrees *South*, he is just seen at Noon in the Horizon; and all the while he is going Southward, and back again, he disappears, being hid just so long as before, at the opposite Time of the Year, he appeared visible.

Let us now bring the *North* Pole into the Zenith, then will the Equinoctial coincide with the Horizon; and consequently all the Northern Parallels are above the Horizon, and the Southern ones below it. Here is but one Day and one Night throughout the Year; it being Day all the while the Sun is to the Northward of the Equinoctial, and Night for the other half Year. All the Stars that have *North* Declination always appear above the Horizon, and at the same Heighth; and all those that are on the other Side, are never seen.

What has been here said of rectifying the Globe to *North* Latitude, holds for the same Latitude *South*; only that before the longest Days were, when the Sun was in ♋: the same happening now when the Sun is in ♑; and so of the rest of the Parallels.

llels, the Seasons being directly opposite to those who live different Hemispheres.

The three foregoing Problems are very useful, as they give a general Idea how the Seasons are altered in all Places of e World, and do very well deserve the particular Attention the Reader; it being undoubtedly entertaining, to know ow these Things are brought about by the regular Course of ature.

For the Sake of the Reader, I shall explain some Things de-ered above in general Terms, by particular *Problems*.

But from what has been already said, we may first make the llowing Observations.

1. *All Places of the Earth do equally enjoy the Benefit of the Sun, in pect of Time, and are equally deprived of it; the Days at one Time of Year being exactly equal to the Nights at the opposite Season.*

2. *In all Places of the Earth, save exactly under the Poles, the Days Nights are of equal Length,* (viz. 12 *Hours each*) *when the Sun is in Equinoctial.*

3. *Those who live under the Equinoctial, have the Days and Nights of equal ngths, at all Times of the Year.*

4. *In all Places between the Equinoctial and the Poles, the Days and hts are never equal, but when the Sun is in the Equinoctial Points* ♈, ♎.

5. *The nearer any Place is to the Equator, the less is the Difference between Length of the Artificial Days and Nights in the said Place; and the more ote, the Greater.*

6. *To all the Inhabitants lying under the same Parallel of Latitude, the s and Nights are of equal Lengths, and that at all Times of the r.*

7. *The Sun is Vertical twice a Year, to all Places between the Tropics; to e under the Tropics, once a Year, but never any where else.*

8. *In all Places between the Polar Circles, and the Poles, the Sun appears e Number of Days without setting; and at the opposite Time of the Year, is for the same Length of Time without rising: and the nearer unto, or ber remote from the Pole, those Places are, the longer or shorter is the 's continued Presence in, or Absence from the same.*

9. *In all Places lying exactly under the Polar Circles, the Sun, when he n the neareſt Tropic appears 24 Hours without setting; and when he is he contrary Tropic he is for the same length of Time without rising; at all other Times of the Year he rises and sets there, as in other ces.*

10. *In all Places lying in the* { *Northern* / *Southern* } *Hemisphere, the longest Day and teſt Night, is when the Sun is in the* { *Northern* / *Southern* } *Tropic; and the contrary.*

PROB.

PROB. VI. *The Latitude of any Place, not exceeding* 66½ *Degrees, and the Day of the Month being given, to find the Time of Sun-riſing and ſetting, and the Length of the Day and Night.*

Having rectified the Globe according to the Latitude, bring the Sun's Place to the Meridian, and put the Hour-Index to 12 at Noon; then bring the Sun's Place to the Eaſtern Part of the Horizon, and the Index will ſhew the Time when the Sun riſes. Again, turn the Globe until the Sun's Place be brought to the Weſtern Side of the Horizon, and the Index will ſhew the Time of Sun-ſetting.

The Hour of Sun-ſetting doubled, gives the Length of the Day; and the Hour of Sun-riſing doubled, gives the Length of the Night.

Let it be required to find when the Sun riſes and ſets at *London* on the 20th of *April*. Rectify the Globe for the Latitude of *London*, and having found the Sun's Place, correſponding to *April* the 20th, *viz.* ♉ 10¾ Degree, bring ♉ 10¾ Degrees to the Meridian, and ſet the Index to 12 at Noon; then turn the Globe about till ♉ 10¾ Degrees be brought to the Eaſtern Part of the Horizon, and we'll find the Index point 4¾ Hours; this being doubled, gives the Length of the Night 9½ Hours. Again, bring the Sun's Place to the Weſtern Part of the Horizon, and the Index will point 7¼ Hours, which is the Time of Sun-ſetting; this being doubled, gives the Length of the Day 14½ Hours.

PROB. VII. *To find in what Latitude the longeſt Day is, of any given Length leſs than* 24 *Hours.*

Bring the Solſtitial Point to the Meridian, and ſet the Index to 12 at Noon; then turn the Globe Weſtward till the Index points at half the Number of Hours given: Which being done, keep the Globe from turning round its Axis, and ſet the Meridian up or down in the Notches, till the Solſtitial Point comes to the Horizon, then that Elevation of the Pole will be the Latitude.

If the Hours given be 16, the Latitude is 49 Degrees; if 17 Hours, the Latitude is 63¼ Degrees.

PROB.

PROB. VIII. *To find in what Latitude the longeſt Day is of any given Length leſs than* 182 *Natural Days, in the* Frigid Zones.

Find a Point in the Ecliptic, half ſo many Degrees diſtant from the Solſtitial Point, as there are Days given, and bring that Point to the Meridian; then keep the Globe from turning round its Axis, and move the Meridian up or down until the foreſaid Point of the Ecliptic comes to the Horizon: That Elevation of the Pole will be the Latitude required.

If the Days given were 78, the Latitude is 71½ Degrees.

This Method is not accurate, becauſe the Degrees in the Ecliptic do not correſpond to Natural Days; and alſo becauſe the Sun does not always move in the Ecliptic at the ſame Rate; however ſuch *Problems* as theſe may ſerve for Amuſements.

PROB. IX. *Concerning the Equation of Civil Days, and to find how much any Number of Days in one Month is longer or ſhorter, than the like Number of Days in another Month, even by the* Globe.

That one Day is longer than another, proceeds from 2 Cauſes *Firſt*, The Sun's apparent Motion is unequal, being ſlower in *Apogee* than in *Perigee*; in the *Firſt*, ſcarce moving 58′ daily, in the other above 61′.

The *Second* is the Difference of Right Aſcenſion, anſwerable to equal Parts of the Ecliptic, being far greater about the Tropics than the Equinoxes.

Now, then ſuppoſe the given Number of Days were 20 in two different Months.

Find the Sun's Places for the Beginning and End of each 20 Days, which will give four Points on the Ecliptic, anſwerable to which, find the Right Aſcenſions of the four Points foreſaid, then ſubtract the Right Aſcenſion of the Beginning from the Right Aſcenſion of the Ending of thoſe Days reſpectively, if the Remains be equal, then are each 20 Days equal to the other: But if one Remainder be greater than the other find their Difference, and change thoſe Degrees and Minutes of Difference of Right Aſcenſion into Time, by allowing 4′ for every Degree, ſo will be found the Difference in Time, that one 20 Days are longer than the other.

PROB. X. *The Day of the Month being given, to find when the Morning and Evening* Twilight *begins and ends, in any Place upon the Globe.*

In the aforegoing *Problems*, by the Length of the Day, we meant the Time from Sun-rising to Sun-set; and the Night was reckoned from Sun-set till he rose next Morning. But it is found by Experience, that *total Darkness* does not commence in the Evening, till the Sun has got 18 Degrees below the Horizon; and when he comes within the same Distance of the Horizon next Morning, we have the first *Dawn of Day*. This faint Light which we have in the Morning and Evening before and after the Sun's rising and setting, is what we call the *Twilight*.

Prob. II. Having rectified the Globe for the Latitude, the Zenith, and the Sun's Place; turn the Globe, and the Quadrant of Altitude until the Sun's Place cuts 18 Degrees below the Horizon, (if the Quadrant reaches so far) then the Index upon the Hour-Circle will shew the Beginning or Ending of Twilight, after the same Manner, as before we found the Time of Sun-rising and setting, in *Prob.* 6. But by Reason of the Thickness of the Wooden-Horizon, we can't conveniently see, or compute when the Sun's Place is brought to the Point aforesaid. Wherefore the Globe being rectified as above directed, turn the Globe, and also the Quadrant of Altitude Westward, until that Point in the Ecliptic, which is opposite to the Sun's Place, cuts the Quadrant in the 18th Degree above the Horizon; then the Hour-Index will shew the Time, when Day breaks in the Morning. And if we turn the Globe and the Quadrant of Altitude, until the Point opposite to the Sun's Place cuts the Quadrant in the 18th Degree in the Eastern Hemisphere; the Hour-Hand will shew, when Twilight ends in the Evening. Or, having found the Time from Midnight when the Morning Twilight begins, if we reckon so many Hours before Midnight, it will give the Time when the Evening Twilight ends. Having found the Time when Twilight begins in the Morning, find the Time of Sun-rising, by *Prob.* 6. and the Difference will be the Duration of Twilight.

Thus at *London*, on the first of *May*, Twilight begins at three Quarters past One o'Clock; the Sun rises at about half an Hour past Four; whence the Duration of Twilight then is 3 Hours, both in the Morning and Evening. On the first of *November*

November, the Twilight begins at half an Hour past Six, being somewhat above an Hour before Sun-rising.

PROB. XI. *To find the Sun's Altitude when it shines, by the Globe.*

Having set the Frame of the Globe truly horizontal or level, turn the *North* Pole towards the Sun, and move the Meridian up or down in the Notches, till the Axis casts no Shadow; then the Arch of the Meridian, contained betwixt the Pole and the Horizon, is the Sun's Altitude.

Note, The best Way to find the Sun's Altitude, is by a little Quadrant graduated into Degrees, and having Sights and a Plummet to it: Thus, hold the Quadrant in your Hands, so as the Rays of the Sun may pass thro' both the Sights; the Plummet then hanging freely by the Side of the Instrument, will cut in the Limb the Altitude required. These Quadrants are to be had at the Instrument-Makers, with Lines drawn upon them, for finding the Hour of the Day, and the Azimuth, with several other pretty Conclusions, very entertaining for Beginners.

PROB. XII. *To find in what Place else, the Sun hath the same Altitude with us, at the same Time.*

This is two-fold: *First*, When the Sun is on the Meridian. *Secondly*, When not.

1. When the Sun is on our Meridian, observe what Place is exactly under the Declination of the Sun, when the Globe is rectified, and the Place brought to the Zenith, to this Place last found rectify the Globe, as before, then turn about the Quadrant, all the Places that pass under any one Degree of the Quadrant have the Sun that same Number of Degrees high.

But when the Sun is not on our Meridian, rectify the Globe, and turn it about till the Index point at our present Hour. 2. Pitch one Foot of a Pair of Compasses in the Sun's Place, extending the other to the Zenith Point on the Meridian. 3. Turn about that Foot back, till it touch the Meridian on some Degree, which is the Latitude of the other Place, and the Longitude is the same as ours.

Before I conclude this, I shall detect one vulgar Error in *Astronomy*. Tho' 'tis true that the Sun comes to the Meridian

of a Place different in Longitude 15 Degrees *Weſt* from *Dublin* exactly one Hour later, but 'tis not always, and exactly true on any other Hour or Azimuth if the Latitude differ.

Now follows an *Example*, plainly elucidating the Truth hereof.

Here the Sun, when in ♋, riſes at half an Hour paſt 3. Now ſuppoſing a Place in Latitude 10 Degrees, but differing in Longitude from *Dublin* 90 Degrees, then and there the Sun riſes about three Quarters paſt 5, unto which add Six Hours, the Difference in Time betwixt the Meridians of the two Places, gives three Quarters paſt 11 with us, when the Sun riſes there, which is no leſs than 8 Hours and a Quarter after Sun-riſe with us, whereas many believe it to be exactly 6 Hours after Sun-riſe with us, but are miſtaken full 2 Hours and a Quarter, and would, whether the Longitude differ or not more or leſs; wherefore have reſpect to the Latitude, when Queſtions of the Sun's preſent Altitude, Azimuth, Riſing and Setting in other Places is required.

Prob. XIII. *The Latitude, and the Day of the Month being given, to find the Hour of the Day when the Sun ſhines.*

Having placed the Wooden Frame upon a Level, and the Meridian due *North* and *South*, rectify the Globe for the Latitude, and fix a Needle perpendicularly over the Sun's Place: The Sun's Place being brought to the Meridian, ſet the Hour-Index to 12 at Noon, then turn the Globe about until the Needle points exactly to the Sun, and caſts no Shadow. and then the Index will ſhew the Hour of the Day.

Prob. XIV. *The Sun's Azimuth being given, to place the Meridian of the Globe due* North *and* South, *or to find a Meridian Line, when the Sun ſhines.*

Let the Sun's Azimuth be 30 Degrees South-Eaſterly, ſet the Horizon of the Globe upon a Level, and bring the *North* Pole into the Zenith; then turn the Horizon about, until the Shade of the Axis cuts as many Hours as is equivalent to the Azimuth, (allowing 15 Degrees to an Hour) in the North-Weſt Part of the Hour-Circle; *viz.* X at Night; which being done, the Meridian of the Globe ſtands in the true Meridian of the

Place.

Place. The Globe ſtanding in this Poſition, if we hang two Plummets at the *North* and *South* Points of the Wooden Horizon, and draw a Line betwixt them, we'll have a Meridian Line; which if it be on a fixed Plane (as a Floor or Window) it will be a Guide for placing the Globe due *North* and *South* at any other Time.

PROB. XV. *The Latitude, Hour of the Day, and the Sun's Place being given, to find the Sun's Altitude and Azimuth.*

Rectify the Globe for the Latitude, the Zenith, and the Sun's Place; then the Number of Degrees contained betwixt the Sun's Place and the Vertex is the Sun's Meridional Zenith-Distance; the Complement of which, to 90 Degrees, is the Sun's Meridian Altitude. If we turn the Globe about until the Index points at any other given Hour, then bringing the Quadrant of Altitude to cut the Sun's Place, we'll have the Sun's Altitude at that Hour; and where the Quadrant cuts the Horizon, is the Sun's Azimuth at the ſame Time. Thus *May* the 9th at *London*, the Sun's Meridian Altitude will be 61½ Degrees; and at 10 o'Clock in the Morning, the Sun's Altitude will be 52 Degrees; and his Azimuth about 50 Degrees from the *South* Part of the Meridian.

PROB. XVI. *The Latitude of the Place, and the Day of the Month being given; to find the Depreſſion of the Sun below the Horizon, and his Azimuth at any Hour of the Night.*

Having rectified the Globe for the Latitude, the Zenith, and the Sun's Place; take a Point in the Ecliptic, exactly oppoſite to the Sun's Place, and find the Sun's Altitude, and Azimuth, as by the laſt *Problem*; and theſe will be the Depreſſion and the Altitude required. Thus, If the Time given be the 9th of *November*, at 10 o'Clock at Night, the Depreſſion and Azimuth will be the ſame as was found in the laſt *Problem*.

PROB.

PROB. XVII. *The Declination and Meridian Altitude of the Sun, or of any Star being given; to find the Latitude of the Place.*

Mark the Point of Declination upon the Meridian, according as it is either *North* or *South*, from the Equator; then ſlide the Meridian up or down in the Notches, till the Point of Declination be ſo far diſtant from the Horizon, as is the given Meridian Altitude; that Elevation of the Pole will be the Latitude.

Thus, If the Sun's, or any Star's Meridian Altitude be 51½ Degrees *South*, and its Declination 11½ Degrees *North*, the Latitude will be 51½ Degrees *North*.

PROB. XVIII. *Two known Stars having the ſame Azimuth, or the ſame Height, being given; to find the Hour of the Night.*

Rectify the Globe for the Latitude, the Zenith, and the Sun's Place.

1. When the two Stars are in the ſame Azimuth. Turn the Globe, and alſo the Quadrant about, until both the Stars incide with the Edge thereof; then will the Index ſhew the Hour of the Night: And where the Quadrant cuts the Horizon, is the common Azimuth of both Stars.

2. If the two Stars are of the ſame Altitude, move the Globe ſo, that the ſame Degree on the Quadrant will cover both Stars; then the Index will ſhew the Hour.

This *Problem* is uſeful when the Quantity of the Azimuth of the two Stars, in the firſt Caſe, or of their Altitude in the latter Caſe, is not known.

PROB. XIX. *The Latitude, Day of the Month, and the Altitude of any known Star being given; to find the Hour of the Night.*

Rectify the Globe for the Latitude, Zenith, and the Sun's Place: Turn the Globe, and the Quadrant of Altitude, backward or forward, till the Center of that Star meets the Quadrant in the Degree of Altitude given; then the Index will point the true Hour of the Night; and alſo where the Quadrant

rant cuts the Horizon, will be the Azimuth of the Star at hat Time.

ROB. XX. *If the Latitude, Sun's Altitude, and his Declination (inſtead of his Place in the Ecliptic) are given; to find the Hour of the Day and Azimuth.*

Rectify the Globe for the Latitude and Zenith; and having rought the *Equinoctial Colure* to the Meridian, ſet the Index to at Noon: Which being done, turn the Globe and the Quarant, until the given Declination in the Equinoctial Colure uts the Altitude on the Quadrant; then the Index will ſhew e Hour of the Day, and the Quadrant cut the Azimuth in e Horizon.

ROB. XXI. *The Day and Hour of a Lunar or Solar Eclipſe being known; to find all thoſe Places upon the Globe in which the ſame will be viſible.*

Find where the Sun is Vertical at the given Hour, and bring at Point to the Zenith; then the Eclipſe will be viſible in all oſe Places that are under the Horizon: Or, if we bring the ntipodes to the Place where the Sun is Vertical, into the nith, we'll have the Places where the Eclipſe will be viſible ove the Horizon.

Note, Becauſe *Lunar* Eclipſes continue ſometimes for a long hile together, they may be ſeen in more Places than one Heſphere of the Earth; for by the Earth's Motion round its is, during the Time of the Eclipſe, the *Moon* will riſe in ſeral Places after the Eclipſe began.

Or, more exactly thus.

Having found the Declination of the Sun, elevate that Pole the Globe which is moſt remote from the Sun, till its Heighth equal to the Sun's Declination, convert the Time of the ginning of the Eclipſe from Noon into Degrees and Mites, and if the Hour given be between Noon and Midnight btract it from the Longitude of the given Place to which is computed; but if it happen between Midnight and the ceeding Noon, add to it the Longitude of the given Place, d bring the Point in the Equinoctial oppoſite to this to Meridian, then a Line drawn by the Eaſtern Edge of the rizon, will paſs thro' all thoſe Places where the Moon aprs to begin to be eclipſed at her Setting; and if from the Degree

Degree of the Equator then under the Meridian, be ſubtracte the Duration of the Eclipſe reduced into Time, and th Globe be turn'd about, till that degree under the Equinoctia come to the Meridian, a Line drawn by the Weſtern Edge o the Horizon will paſs thro' all thoſe Places where the Eclipſe will end, at the Time of the Moon's Riſing, and conſequent ly within all that Tract of the Earth's Superficies will the E clipſe be viſible.

But for a Solar Eclipſe.

When an Eclipſe of the Sun is Central, if we brin the Place where the Sun is Vertical at that Time, into the Z nith, ſome Part of the Eclipſe will be viſible in moſt Plac within the upper Hemiſphere: But by reaſon of the ſhort D ration of Solar Eclipſes, and the Latitude which the Moo commonly has at that Time, (tho' but ſmall) there is no ce tainty in determining the Places where thoſe Eclipſes will b viſible, by the Globe; but recourſe muſt be had to Calcu tions. Howbeit, by the Globes we thus come to a near A proximation.

Firſt, Say, As the Semidiameter of the Earth's Diſk ſeen from t Moon : is to 89 *Degrees : : So is the Arch between the Centers of the and Penumbra : to the Degree of a great Circle belonging to it : : An is the Semidiameter of the Penumbra : to its Degrees.*

2. Then bring to the Meridian the Place lying vertica under the Sun, and from thence *South* or *North*, according the Moon's Latitude, number as many Degrees as anſwer to t Arch between the Centers firſt found, the End of this Num ration gives the Place of the Earth lying in the Center of t Penumbra. 3. In this Center ſet one Foot of the Compaſ and the other Foot being turned about at the Diſtance of a Degree anſwering to the Semidiameter of the Penumbra afo ſaid, ſhews that all thoſe Parts of the Earth includ within its Ambit are to ſuffer the Eclipſe; and conſequen will ſee an apparent one in the Sun. A greater Eclipſe t nearer they lye to the Center of the Penumbra aforeſaid: F if this Semidiameter of the Penumbra on the Globe be divi into 12 equal Parts, thro' which, if Concentric Circles drawn, then may the Digits of the Eclipſe in thoſe Places eſtimated. where the Center falls is either a total or annu Eclipſe: In the Circle next it is an Eclipſe of 11 Digits, n that, of 10, next that, of 9 Digits, and ſo on.

PRO

ROB. XXII. *To find all that Space upon the Earth, where an Eclipſe of one of the Satellites of* Jupiter *will be viſible.*

Having found that Place upon the Earth, in which the Sun Vertical, at the Time of the Eclipſe. Elevate the Globe according to the Latitude of the ſaid Place; then bring the ace to the Meridian, and ſet the Hour-Index to 12 at Noon. *Jupiter* be in Conſequence of the Sun, draw a Line with ack-Lead, or the like, along the Eaſtern Side of the Horizon, ich Line will paſs over all thoſe Places where the Sun is ting at that Time: Then count the Difference betwixt the ght Aſcenſion of the Sun, and that of *Jupiter*; and turn Globe Weſtward, until the Hour-Index points to this Difence; then keep the Globe from turning round its Axis, elevate the Meridian, according to the Declination of iter. The Globe being in this Poſition, draw a Line along Eaſtern Side of the Horizon, then the Space between this e, and the Line before drawn, will comprehend all thoſe ces of the Earth, where *Jupiter* will be viſible, from the ing of the Sun, to the ſetting of *Jupiter*.

But if *Jupiter* be in Antecedence of the Sun, (*i. e.* riſes be- e him) having brought the Place where the Sun is Vertical, the Zenith, and put the Hour-Index to 12 at Noon, draw ine on the Weſtern Side of the Horizon; then elevate the be according to the Declination of *Jupiter*, and turn it a- t Eaſtwards, until the Index points to ſo many Hours di- nt from Noon, as is the Difference of Right Aſcenſion of Sun and *Jupiter*. The Globe being in this Poſition, draw ine along the Weſtern Side of the Horizon; then the Space ntained between this Line, and the other laſt drawn, will nprehend all thoſe Places upon the Earth, where the Eclipſe viſible, between the Riſing of the Sun and *Jupiter*.

ROB. XXIII. *To find the Right Aſcenſion and Declination of the Sun or any Fixed Star.*

Bring the Sun's Place in the Ecliptic to the Meridian, then t Degree of the Equator, which is cut by the Meridian, will the *Sun's Right Aſcenſion*; and that Degree of the Meridian, ich is exactly over the Sun's Place, is the *Sun's Declination*. ter the ſame Manner, bring the Place of any Fixed Star to

the Meridian, and we'll find its Right Aſcenſion in the Equinoctial, and Declination on the Meridian.

Thus, the *Right Aſcenſion* and *Declination* is found, after the ſame Manner as the Longitude and Latitude of a Place upon the *Terreſtrial* Globe.

Note, The *Right Aſcenſion* and *Declination* of the Sun vary every Day; but the *Right Aſcenſion, &c.* of the Fixed Stars is the ſame throughout the Year. *

		The Sun's Right Aſcenſion. Deg.	Declination Deg.
Thus on	*January* 20	314	17⅓ S.
	March 25	14	6 N.
	July 10	120¼	20¼ N.
	November 15	242	21 S.

		Right Aſcenſion. Deg.	Declination Deg.
of	*Aldebaran*	65	16 N.
	Spica Virginis	197¾	9¾ S.
	Capella	74	45⅔ N.
	Syrius, or the Dog-Star	98¼	16⅓ S.

Note, The *Declination* of the Sun may be found after the ſame Manner, by the *Terreſtrial* Globe; and alſo his *Right Aſcenſion*, when the Equinoctial is numbred into 360 Degrees, commencing at the Equinoctial Point ♈.

By the Converſe of this *Problem*, having the *Right Aſcenſion* and *Declination* of any Point given, that Point it ſelf may be eaſily found upon the Globe.

Prob. XXIV. *To find the Longitude and Latitude of a given Star.*

Having brought the Solſtitial Colure to the Meridian, ſet the Quadrant of Altitude over the proper Pole of the Ecliptic, whether it be *North* or *South*; then turn the Quadrant over the given Star; and the Arch contained betwixt the Star and the Ecliptic, will be the Latitude, and the Degree cut on the Ecliptic will be the Star's Longitude.

* The inſenſible Change in the Longitude, Right Aſcenſion, and Declination of the Fixed Stars, made by their ſlow Motion, parallel to the Ecliptic (being but 1 Degree in 72 Years) is not worth Notice in this Place.

Thus

Thus, the Latitude of *Arcturus* will be found to be 31 Degrees *North*, and the Longitude 200 Degres from ♈, or 20 Degrees from ♎: The Latitude of *Fomahaut* in the Southern Fish, 21 Degrees *South*, and Longitude 299½ Degrees, or ♑ 29½ Degrees. By the Converse of this Method, having the Latitude and Longitude of a Star given, it will be easy to find the Star upon the Globe.

The Distance betwixt two Stars, or the Number of Degrees contained between them, may be found, by laying the Quadrant of Altitude over each of them, and counting the Number of Degrees intercepted; after the same manner, as we found the Distance betwixt two Places on the *Terrestrial* Globe.

PROB. XXV. *The Latitude of the Place being given; to find the Amplitude, Oblique Ascension and Descension, Ascensional Difference; Semi-Diurnal Arch, and the Time of Continuance above the Horizon, of any given Point in the Heavens.*

Having rectified the Globe for the Latitude, and brought the given *Point* to the Meridian, set the Index to the Hour of 12; then turn the Globe until the given Point be brought to the Western Side of the Horizon, and that Degree of the Equinoctial which is cut by the Horizon at that Time, will be the *Oblique Ascension*; and where the given Point cuts the Horizon, is the *Amplitude Ortive*: If the Globe be turned about until the given Point be brought to the Western Side of the Horizon, it will there shew the *Amplitude Occasive*; and where the Horizon cuts the Equinoctial at that Time, is the *Oblique Descension*.

The Time between the Index at either of these two Positions, and the Hour of 6, or the Difference between the Oblique Ascension and Right Ascension, is the *Ascensional Difference*. If the Place be in *North* Latitude, and the Declination of the given Point be {*North* / *South*} the Ascensional Difference reduced to Time, and {added to / subtracted from} 6 o'Clock, gives the *Semi-Diurnal Arch*; the Complement whereof to a Semicircle, is the *Semi-Nocturnal Arch*. If the Place be in *South* Latitude, then the contrary is to be observed with respect to the Declination.

The Semi-{Diurnal / Nocturnal} Arch being doubled, gives the Time of Continuance {above / below} the Horizon. Or the Time of Continuance above the Horizon, may be found by counting the Num-

Number of Hours contained in the upper Part of the Horary Circle, betwixt the Places where the Index pointed, when the given Point was in the Eaſtern and Weſtern Parts of the Horizon. If the given Point was the Sun's Place, the Index pointed the Time of his Riſing and Setting, when the ſaid Place was in the Eaſtern and Weſtern Parts of the Horizon. Or the Time of Sun-riſing may be found by adding or ſubtracting his Aſcenſional Difference, to or from the Hour of Six, according as the Latitude and Declination are either contrary or the ſame Way.

Thus, at *London* on the 20th of *April*, the *Sun's*
- *Amplitude*, is 24 Degrees Northerly.
- *Oblique Aſcenſion*, 20.
- *Oblique Deſcenſion*, 58.
- *Aſcenſional Difference*, 19.
- *Semi-Diurnal Arch*, 109.
- Continuance above the Horizon 14 Hours.

Sun riſes at three Quarters paſt Four.
Sun ſets at a Quarter paſt Seven.

Theſe Things for the Sun vary every Day; but for a fixed Star, the Day of the Month need not be given, for they are the ſame all the Year round.

Thus the ſeveral Requiſites for the Stars *Aldebaran*, *Caſtor*, *Regel* and *Syrius*, will be found as follows.

For	*Aldebaran*	*Caſtor*	*Regel*	*Syrius*
Right Aſcenſion	65 03	109 16	75 21	98 16
Declination	15 55 N	32 27 N	08 33 S	16 21 S
Meridional Altitude	54 23	70 55	29 55	22 07
Meridional Zenith-diſtance	35 37	19 05	60 05	67 53
Oblique Aſcenſion	44 00	56 06	64 27	76 36
Amplitude	26 09 N	59 36 N	13 50 S	26 54 S
Oblique Deſcenſion	86 06	162 26	86 15	119 56
Aſcenſional Difference	21 03	53 10	10 54	21 40

PROB. XXVI. *The Latitude and the Day of the Month being given; to find the Hour, when a known Star will be on the Meridian, and alſo the Time of its Riſing and Setting.*

Having rectified the Globe for the Latitude and the Sun's Place; bring the given Star to the Meridian, and alſo to the

East or *West* Side of the Horizon, and the Index will ſhew accordingly, when the Star Culminates, or the Time of its Riſing or Setting.

Thus at *London* on the 10th of *January*, *Syrius* will be upon the Meridian at a Quarter paſt Ten in the Evening; riſes at 5¼ Hours, and ſets at three Quarters paſt two in the Morning.

By the Converſe of this *Problem*, knowing the Time, when any Star is upon the Meridian, we may eaſily find the *Sun's Place*. Thus, bring the given Star to the Meridian, and ſet the Index to the given Hour; then turn the Globe until the Index points to 12 at Noon, and the Meridian will cut the *Sun's Place* in the Ecliptic. Thus when *Syrius* comes to the Meridian at 10¼ Hours after Noon, the *Sun's Place* will be ♒ 1¼ Degrees.

PROB. XXVII. *To find at what Time of the Year a given Star will be upon the Meridian, at a given Hour of the Night.*

Bring the Star to the Meridian, and ſet the Index to 12 at Noon, then turn the Globe till the Index points to the given Hour, and the Meridian will cut the Ecliptic in the Sun's Place; whence the Day of the Month may be eaſily found in the *Kalendar* upon the Horizon.

PROB. XXVIII. *The Latitude of the Place being given, to find the Hour of the Day, when the Sun ſhines.*

If it be in the Summer, elevate the Pole according to the Latitude, and ſet the Meridian due *North* and *South*; then the Shadow of the Axis will cut the Hour on the Dial-Plate: For the Globe being rectified in this Manner, the Hour-Circle is a true *Equinoctial-Dial*; the Axis of the Globe being the *Gnomon*. This holds true in *Theory*, but it might not be very accurate in *Practice*, becauſe of the Difficulty in placing the Horizon of the Globe truly Horizontal, and its Meridian due *North* and *South*.

If it be in the Winter Half-Year, elevate the *South* Pole according to the Latitude *North*; and let the *North* Part of the Horizon lie in the *South* Part of the Meridian: Then the Shade of the Axis will ſhew the Hour of the Day as before. But this cannot be ſo conveniently performed, tho' the Reaſon is the ſame as in the former Caſe.

PROB.

PROB. XXIX. *The Latitude, the Sun's Place and his Altitude, being given; to find the Hour of the Day, and the Sun's Azimuth from the Meridian.*

Having rectified the Globe for the Latitude, the Zenith, and the Sun's Place; turn the Globe, and the Quadrant of Altitude, ſo that the Sun's Place may cut the given Degree of Altitude; then the Index will ſhew the Hour, and the Quadrant will cut the Azimuth in the Horizon. Thus, If at *London*, on the 10th of *Auguſt*, the Sun's Altitude be 36 Degrees in the Forenoon, the Hour of the Day will be IX, and the Sun's Azimuth about 58 Degrees from the *South* Part of the Meridian.

PROB. XXX. *The Latitude, the Sun's Place and his Azimuth being given; to find his Altitude and the Hour.*

Rectify the Globe for the Latitude, the Zenith, and Sun's Place; then put the Quadrant of Altitude to the Sun's Azimuth in the Horizon, and turn the Globe till the Sun's Place meet the Edge of the Quadrant; then the ſaid Edge will ſhew the Altitude, and the Index point to the Hour. Thus, *May* the 10th at *London*, when the Sun is due *Eaſt*, his Altitude will be about 24 Degrees, and the Hour about VII in the Morning. And when his Azimuth is 60 Degrees South-Weſterly, the Altitude will be about 44½ Degrees, and the Hour about 2¾ in the Afternoon.

Thus, the Latitude and the Day being known, and having beſides either the Altitude, the Azimuth, or the Hour; the other two may be eaſily found.

PROB. XXXI. *The Latitude, the Sun's Altitude, and his Azimuth, being given; to find his Place in the Ecliptic and the Hour.*

Rectify the Globe for the Latitude and Zenith, and ſet the Edge of the Quadrant to the given Azimuth; then turning the Globe about, that Point of the Ecliptic which cuts the Altitude, will be the Sun's Place. Keep the Quadrant of Alti-

tude in the ſame Poſition, and having brought the Sun's Place to the Meridian, and the Hour-Index to 12 at Noon; turn the Globe about till the Sun's Place cuts the Quadrant of Altitude, and then the Index will point to the Hour of the Day.

PROB. XXXII. *Given the Time that a Star comes to the Meridian; to find the Sun's Place.*

Bring the Star to the Meridian, ſet the Index to the given Time, turn the Globe about till the Index point to 12 at Noon; then will the Meridian cut the Ecliptic in the Sun's Place.

PROB. XXXIII. *The Day of the Month, and the Azimuth of any known Star being given; to find the Hour of the Night.*

Having rectified the Globe for the Latitude and the Sun's Place; if the given Star be due *North* or *South*, bring it to the Meridian, and the Index will ſhew the Hour of the Night. If the Star be in any other Direction, fix the Quadrant of Altitude in the Zenith, and ſet it to the Star's Azimuth in the Horizon; then turn the Globe about until the Quadrant cuts the Center of the Star, and the Index will ſhew the Hour of the Night.

The Bearing of any Point in the Heavens may be found by the following Methods.

Having a Meridian-Line drawn in two Windows, that are oppoſite to one another, we may croſs it at Right Angles with another Line, repreſenting the *Eaſt* and *Weſt*; from the Point of Interſection deſcribe a Circle, and divide each Quadrant into 90 Degrees; then get a ſmooth Board, of about 2 Feet long, and ¾ Foot broad, (more or leſs as may be judged convenient) and on the back Part of it fix another ſmall Board Croſswiſe, ſo that it may ſerve as a Foot to ſupport the biggeſt Board upright, when it is ſet upon a Level, or an Horizontal Line. The Board being thus prepared, ſet the lower Edge of the ſmooth, or Fore-Side of it, cloſe to the Center of the Circle, then turn it about to the Meridian, or to any Azimuth Point required, (keeping the Edge of it always cloſe to the Center) and caſting our Eye along the flat Side of it, we'll eaſily perceive what Stars are upon the Meridian, or any other Bearing that the Board is ſet to.

PROB.

PROB. XXXIV. *If two Stars were given, one on the Meridian, and the other in the* East *or* West *Part of the Horizon; to find the Latitude.*

Bring that Star, which was obſerved on the Meridian, to the Meridian of the Globe, and keep the Globe from turning round its Axis; then ſlide the Meridian up or down in the Notches till the other Star is brought to the *Eaſt* or *Weſt* Part of the Horizon, and that Elevation of the Pole will be the Latitude ſought.

PROB. XXXV. *Given two Altitudes of the Sun and Space of Time between the Obſervations; to find the Latitude of ſuch a Place.*

Take the Complement of Altitude of the firſt Obſervation in the Compaſſes, and ſet one Foot in the Sun's Place, and ſweep a Circle on the Globes Surface with the other; then bring the Sun's Place to the Meridian, and turn the Globe *Eaſt*, till ſo many Degrees as anſwer to the Space of Time paſs thro' it; then under the Declination mark the Place the Meridian cuts, and ſet one Foot of the Compaſſes in it, with the other extended to the Complement of Altitude of the ſecond Obſervation, croſs the former Circle in the Vertical Point, or Zenith of the Place, which bring to the Meridian, thereon is the Latitude ſought.

PROB. XXXVI. *Given the Sun's Declination and Amplitude; to find the Latitude.*

Elevate the Pole ſo many Degrees as the Complement of the Amplitude is, and ſcrew the Quadrant in the Zenith, and bring the firſt Point of ♈ to the Meridian; then count on the Quadrant of Altitude to the Degree of the Sun's Declination, and bring that Degree to the Equinoctial, and the Degree of the Equinoctial cut by that Degree of the Quadrant of Altitude, is the Degree of Latitude ſought.

PRO

PROB. XXXVII. *Given the Sun's Amplitude and Difference of Aſcenſion; to find the Latitude and Sun's Declination.*

Elevate the Pole ſo many Degrees as the Sun's Difference of Aſcenſion is, and ſcrew the Quadrant of Altitude to the Zenith, and bring the firſt Point of ♈ to the Meridian, then number on the Quadrant of Altitude the Complement of the Sun's Amplitude, and move the Quadrant of Altitude, till that Number of Degrees cuts the Equator, ſo ſhall the Quadrant cut in the Horizon the Degree of Latitude, and in the Equator the Sun's Declination.

PROB. XXXVIII. *The Sun's Declination and Hour at* East *given; to find the Latitude.*

Elevate the Pole ſo many Degrees as the Sun's Declination and ſcrew the Quadrant of Altitude in the Zenith, then change the Time after 6 of its being due *Eaſt* into Degrees and Minutes, which Number in the Horizon from the *Eaſt* Southwards, and bring the Quadrant of Altitude to that Degree, ſo will the Degree of the Quadrant cut by the Equator be the Complement of the Latitude ſought.

PROB. XXXIX. *Given the Day of the Month, and Hour of the Night, and a known Star, either Riſing or Setting; to find the Latitude.*

Rectify the Globe, and turn the Globe till its Hour-Index ſtand at the given Hour, and there faſten the Globe; then turn the Meridian thro' the Notches of the Horizon, till the known Star come to the *Eaſt*-Side of the Horizon, if Riſing, or the *Weſt*, if Setting; ſo ſhall the Elevation of the Pole then be the Latitude ſought.

PROB. XL. *By the Sun's Declination and Azimuth at Six; to find the Latitude and Altitude.*

Elevate the Pole ſo many Degrees as is the Sun's given Azimuth, and ſcrew the Quadrant in the Zenith: Bring the

firſt Point of ♈ to the Meridian, then number on the Qu drant of Altitude upwards the Complement of the Sun's D clination, and bring that Degree to the Equator, ſo ſha the Degree of the Horizon cut by the Quadrant of Altitu be the Complement of the Latitude, and the Degree of t Equator cut by the Quadrant, ſhall be the Altitude of t Sun at 6 of the Clock.

PROB. XLI. *The Sun's Declination and Altitu at* Eaſt *given; to find the Latitude.*

Elevate the Pole to the Complement of the Sun's given titude, and ſcrew the Quadrant to the Zenith; then bring Equinoctial Point ♈ to the Meridian, and number on Quadrant of Altitude the Degree of the Sun's Declinatio and bring that Degree to the Equinoctial, and note the D gree it cuts; for its Complement to 90 is the Latitude ſoug

Or,

With a Pair of Compaſſes, take from the Equator the D gree of Altitude given, then place one Foot in the Beginni of ♈ on the inner Edge of the Horizon, and extend the ot directly upwards towards the Zenith, then move Brazen Meridian thro' the Notches of the Horizon, till other Point of the Compaſſes reach the Parallel of the Su Declination; ſo ſhall the Number of Degrees that the Pol elevated above the Horizon be the Latitude ſought; which either *North* or *South*, according as the Sun's Declination is.

PROB. XLII. *If the Altitude of two Stars the ſame Azimuth, were given; to find the La tude of the Place.*

Set the Quadrant over both Stars at the obſerved Degree Altitude, and keep it faſt upon the Globe with your Finge then ſlide the Meridian up or down in the Notches, till Quadrant cuts the given Azimuth in the Horizon; that Ele tion of the Pole will be the Latitude required.

PRO

PROB. XLIII. *Having the Latitude of the Place, to find the Degree of the Ecliptic, which riſes or ſets with a given Star; and from thence to determine the Time of its* Coſmical *and* Achronical *Riſing and Setting.*

Having rectified the Globe for the Latitude, bring the given r to the Eaſtern Side of the Horizon, and mark what De- e of the Ecliptic riſes with it: Look for that Degree in e Wooden Horizon, and right againſt it in the Kalendar, 'll find the Month and Day, when the Star *riſes Coſmically.* If bring the Star to the Weſtern Side of the Horizon, that gree of the Ecliptic which riſes at that Time, will give the y of the Month, when the ſaid Star *ſets Coſmically.* So likewiſe a- inſt the Degree which ſets with the Star, we'll find the Day the Month of the *Achronical Setting*; and if we bring it to Eaſtern Part of the Horizon, that Degree which ſets at that me will be the Sun's Place when the Star *riſes Achronically.*

Thus, in the Latitude of *London*, *Syrius*, or the *Dog-Star*, riſes *nically* the 30*th* of *July*; and ſets *Coſmically* the 30*th* of *October*. *ebaran*, or the *Bull's Eye*, riſes *Achronically* on the 11*th* of *May*, l ſets *Achronically* on the 8*th* of *December*.

PROB. XLIV. *Having the Latitude of the Place, to find the Time when a Star riſes and ſets* Heliacally.

Having rectified the Globe for the Latitude, bring the Star to Eaſtern Side of the Horizon, and turn the Quadrant round the Weſtern Side, till it cuts the Ecliptic in twelve Degrees Altitude above the Horizon, if the Star be of the firſt Mag- ude; then that Point of the Ecliptic which is cut by the adrant, is 12 Degrees high, above the Weſtern Part of the rizon, when the Star riſes; but at the ſame Time the op- ite Point in the Ecliptic is 12 Degrees below the Eaſtern t of the Horizon, which is the Depreſſion of a Star of the *Magnitude*, when it *riſes Heliacally*; or has got ſo far from the n's Beams, that it may be ſeen in the Morning before Sun- ng. Wherefore look for the ſaid Point of the Ecliptic on Horizon, and right againſt it will be the Day of the Month en the Star *riſes Heliacally*. To find the *Heliacal Setting*: Bring Star to the Weſt-Side of the Horizon, and turn the Qua- nt about to the Eaſtern Side, till the 12*th* Degree of it a-

bove the Horizon cuts the Ecliptic; then that Degree of th Ecliptic, which is oppoſite to this Point, is the Sun's Pla when the Star *ſets Heliacally.*

Thus, we'll find that *Arcturus* riſes *Heliacally* the 17*th* of Se *tember*; and ſets *Heliacally*, *November* the 21*ſt*.

PROB. XLV. *To find the Place of any Planet u on the Globe; and ſo by that Means, to find i Place in the Heavens: Alſo to find at what Ho any Planet will riſe or ſet, or be on the Meridia any Day in the Year.*

We muſt firſt ſeek in an *Ephemerides*, (*Parker's Ephemeris* will well enough) for the Place of the Planet propoſed on th Day; then mark that Point of the Ecliptic either with Cha or by ſticking on a little black Patch; and then for that Nig we may perform any *Problem*, as before, by a Fixed Star.

Let it be required to find the Situation of *Jupiter* among t Fixed Stars in the Heavens, and alſo what Time it riſes a ſets, and comes to the Meridian, on the 20*th* of *November*, 17 at *London*.

Looking for the 20*th* of *November*, 1730, in *Parker's Ephem* I find that *Jupiter's* Place at that Time is in about 9 Degrees ♍; Latitude 1 Degree *North*. Then looking for that Point u on the Celeſtial Globe, I find that ♃ is then among the ſm Stars that lie under the Belly of the Conſtellation *Leo*.

To find when he riſes and ſets, and comes to the Meridi Having put a little black Patch on the Place of *Jupiter*, elev the Globe according to the Latitude; and having brou the Sun's Place to the Meridian, ſet the Hour-Index to 12 Noon: Then turning the Mark which was made for *Jupiter*, the Eaſtern Part of the Horizon, I find ♃ will riſe at about Quarter paſt 11 o'Clock at Night; and turning the Globe bout, I find it comes to the Meridian a little after Six in t Morning; and ſets about 1 o'Clock in the Afternoon.

This Example being underſtood, it will be eaſy to find wh either of the other two ſuperior Planets, *viz. Mars* and *Satu* Riſe, Set, and come to the Meridian.

Gnom

GNOMONICAL or DIALLING PROBLEMS,

Solv'd by the

GLOBES.

SECT. IV.

DIALS take their Names from the Circles of the Sphere to which their Planes are parallel; or with whoſe Planes they coincide.

I. The *Hour-Lines* are the common Sections of the Hour-Circles the Sphere with thoſe Planes.

II. The *Stile* or *Gnomon* is a Line parallel to the common ction of the Planes of all the Hour-Circles of the Sphere, *i. e.* rallel to the Axis of the World. Hence,

The Elevation of the Stile above the Dial-Plane muſt be al-ys equal to the Elevation of the Axis of the World above Plane of the Circle to which the Dial-Plane is parallel; the Stile muſt always be directed towards the elevated le.

III. A *Horizontal* Dial is whoſe Plane is parallel to the Ho-on.

IV. A *Vertical* Dial is whoſe Plane coincides with that of ne Vertical Circle.

V. A

V. A *Direct Erect* Vertical Dial is whoſe Plane is perpendicular to the Horizon, and whoſe Face looks directly *South* or *North*.

VI. An *Erect Declining* Vertical Dial is whoſe Plane is perpendicular to the Horizon, but its Face declines from *South* or *North* Eaſtward or Weſtward.

VII. A *Direct Reclining* Vertical Dial is whoſe Plane looks directly *South* or *North*, but falls back from the Zenith.

VIII. A *Direct Reclining* Vertical Dial whoſe Reclination is towards the ſame Parts with the Latitude of the Place, and equal to the Co Latitude, is called a *Polar Dial*, its Plane paſſing through the Poles of the World.

IX. A *Direct Inclining* Vertical Dial is whoſe Plane looks directly *South* or *North*; but makes an acute Angle with the Horizon.

X. If the Latitude of the Place and the Inclination of the Plane be towards contrary Parts, and the Inclination equal to the Co-Latitude, that Dial is called an *Equinoctial Dial*.

N. B. Every Dial-Plane having two Faces, it is plain, the upper Face of the Equinoctial Dial ſhall have its Reclination equal to the Latitude, and the under Face of the Polar Dial an Inclination equal to the Latitude.

XI. From what has been ſaid, it may be eaſily known what is meant by *Reclining Declining*, and *Inclining Declining* Vertical Dials.

XII. An *Erect* Vertical Dial whoſe Face looks directly *Eaſt* or *Weſt*, is called a *Meridian-Dial*.

XIII. The *Subſtilar* is the Line in the Dial-Plane, upon which the Stile is ſet: It is the common Section of the Dial-Plane and the Plane of a great Circle paſſing thro' the Poles of the World and thoſe of the Plane.

PROBLEM I.

To find the Inclination of a Plane. Plate 2. Fig.

Let AB be a Plane inclin'd to the Horizon HR apply to the Plane, AB a Quadrant DCF, ſo as the Plummet CE may ſtrike the Surface of the Quadrant, I ſay, the Arch DE is the Meaſure of the Angle of Inclination ABH. Draw BG at Right-Angles to HR, becauſe CE is Parallel to BG, the Angle ECF is equal to CBG but DCF is equal to GBH both being Right-Angles. the Angle DCF leſs ECF is equal to GBH leſs CBG, that is, DCE is equal to ABH. Q.E.

PROB

PROB. II. *To find the Reclination of a Plane.*

Plate 2. Fig. 2.

Let AB be the reclining Plane. Draw BG perpendicular to HR, repreſenting the Prime Vertical: ſo ABG is the Angle of Reclination. Raiſe KL perpendicular to AB, apply a Quadrant CDF to KL; ſo as the Plum-Line CE may ſtrain the Face of the Quadrant, I ſay, DE is the Meaſure of the Angle of Reclination ABG.

In the Right-angle Triangle NBK the Angles BNK more NBK are equal to a Right Angle equal to DCF: But, becauſe CE is parallel to BG, the Angle ECF is equal to BNK, therefore DCE is equal to NBK. *Q. E. D.*

PROB. III. *To find the Declination of any Plane.* Plate 2. Fig. 3.

Take a Piece of Board, whoſe upper Surface is a Right-angled Parallelogram as DB, on it deſcribe a Circle CXZ; on the Center C erect a Pin perpendicularly. Draw FG parallel to BE, M*n* perpendicular to BE, LN perpendicular to FG, and place the Plane DB horizontally, with the Side BE applied to the Dial-Plane: Obſerve when the Shadow of the Top of the Pin is on the Periphery of the Circle as at *z* in the Forenoon, and at *x* in the Afternoon the ſame Day; biſect the Arch *xz* with the Diameter KL. 'tis plain KL is the Meridian, and KLN equal to KM*n* is the Angle of Declination.

PROB. IV. *To make an* Horizontal Dial.

The Operation by the GLOBE.

Elevate the Pole to the Latitude of the Place for which we would make our *Dial* (ſuppoſe to *London*, in the Latitude of 51°. 30′.) and bring the *Vernal Colure* to the *Meridian*, and the *Hour-Index* to 12 on the *Hour-Circle*.

d turning the	1	a Clock, or till 15°. of	11°	50′	
be Weſt-	2	the Equator paſs through	24	20	
rds, till the	3	the Meridian, and the	38	03	From the
ex point to	4	Colure will cut the Ho-	53	36	Meridian.
	5	rizon in	71	06	
	6		90	00	

Theſe

Theſe are the Diſtances of the Hour-Lines from Noon till 6 at Night, and the ſame Diſtances ſerve for the Hours betwixt 6 in the Morning, and 12 at Noon, for the one a Clock Hour-Line in the Afternoon is equidiſtant from the Meridian, or Noon-Line, with the 11 a Clock Hour-Line before Noon, and ſo all the other Morning Hour-Lines are diſtant from the Noon-Line by the ſame Space that the ſame Number after Noon-Hour-Lines (numbred from the Meridian on the contrary Side of the Noon-Line) are diſtant from the Meridian.

If we would have the half Hour-Lines placed on our *Dial*, we muſt turn the Globe till the Index points to every half Hour on the Hour-Circle. and mark the Degrees of the Horizon, cut by the Vernal Colure, for thoſe are the Degrees belonging to the half Hours required.

The Geometrical Conſtruction *of this* DIAL.

1. Upon the Plane on which we deſign to draw our *Dial* (as in Plate 2. Fig. 4.) draw a right Line A B. repreſenting the Meridian of our Globe, and the Hour-Line of 12.

2. Towards one End of this Line, aſſign a Point C, repreſenting the Center of our Dial, and through that Point draw another Line at Right Angles to A B, which ſhall be the Hour-Line at 6, as the Line K M; and upon the Point C. with the *Radius* of ſome Line of *Chords*, deſcribe a Semicircle D E F.

3. Then ſeeing 11 and 1 a Clock are diſtant from the Meridian 11 Deg. 50 Min. take 11 Deg. 50 Min. from our Line of *Chords*, and ſet it upon the Semicircle from E to 11. and from E to 1, and draw the Lines C 11, and C 1, for the Hour-Lines between 11 and 1.

4. The Diſtance of 10 and 2. being 24 Deg. 20 Min. we muſt take from our Line of *Chords* 24 Deg. 20 Min. and ſet it from E to 10, and from E to 2. and draw the Hour-Lines of 10 and 2. do thus with the reſt of the Hour-Lines, till 6 in the Morning and 6 at Night; and for the Hour-Lines of 4 and 5 in the Morning, and of 7 and 8 at Night: Continue the Hour-Lines of 4 and 5 in the Afternoon thro' the Center to the other Side of the *Dial*. and they will be the Hour-Lines of 4 and 5 in the Morning; and the Hour-Lines of 7 and 8 in the Forenoon continued will be the Hour-Lines of 7 and 8 in the Afternoon.

5. For the *Stile* or *Cock* of our *Dial* take 51 Deg. 30 Min. the Latitude from our Line of *Chords*, and ſet that Diſtance upon the Semicircle from E to G. and draw the Line C G for the Stile, which muſt ſtand upon the Line of 12. without inclining to the *Eaſt* or *Weſt*, and ſo is our *Dial* finiſhed.

PRO

PROB. V. *By one Poſition of the* Globe, *to find the* Hour-Lines *in all manner of Planes.*

Let a Meridian from Pole to Pole paſs thro' every 15 Degrees of the Equinoctial, to repreſent the Horary Motion of the Sun, both Day and Night; then rectify the Globe to the Latitude, bring alſo one of thoſe Meridians under the brazen Meridian, all the reſt of the Meridian-Lines ſhall cut any Circle, repreſenting the Plane of a Dial, in the Number of Degrees on the ſame Circle that each reſpective Hour-Line is diſtant from the Noon-Line Point in the ſame Circle.

PROB. VI. *To find in what Place of the Earth any manner of* Plane, *that in their Latitude is not* Horizontal, *ſhall become* Horizontal.

Seeing all Manner of Planes, however ſituate, are parallel to ſome Country on the Earth, therefore what is not Horizontal in one Place, may become ſo in another Latitude, and an Horizontal Dial made for it will anſwer.

Thus, an *Erect direct South* or *North Dial* becomes an Horizontal Dial in the ſame Longitude, but whoſe Latitude ſhall be the Complement; wherefore an Erect Direct Dial is the ſame with the Horizontal in the Latitude 45; and an Erect Plane under the Pole will be an Horizontal under the Equator, and an Erect in the Latitude 30, will be an Horizontal in the Latitude 60, and *contra*.

But if the Plane be an Erect Decliner, it ſhall be an Horizontal Plane, at that Point of the Globe, which is againſt the Degree of Declination found on the Horizon; the Latitude and Longitude of which Point find by the Globe, and if the Plane declines Weſtward, the Sun comes ſooner to the Meridian of it, than to the Meridian of the Place where it becomes an Horizontal Plane, and that by ſo many Hours or Minutes as the Difference of Longitude amounts to; but if Eaſtward, then it comes ſo much later.

If the Plane be a direct Recliner, the Complement of the Plane's Reclination is the Latitude, where it becomes an Horizontal one in the ſame Longitude.

If it be a *Declining Recliner*, Rectify the Globe according to the Latitude given, bring the Place to the Meridian, and the Quadrant to the Zenith, which turn to the Declination on the Horizon, and on the Quadrant count upwards the Re-

clination, by which Degree make a Prick on the Globe, which find both the Latitude and Longitude for the true Pla where ſuch a Plane becomes an Horizontal one, the Diſ rence of Longitude change into Time, for the Difference th the Sun makes betwixt the two Meridians.

PROB. VII. *To make a* Dial *on the* Globe, *th ſhall ſhow the Hour of the Day, without a* Gn mon.

Divide the Equinoctial or Middle Circle into 24 equal Par with two twelves, as we count the Hours, then elevate it a cording to the Latitude, and place one 12 due *North*, and t other 12 due *South*, when the Sun ſhines on it the Globe w be divided into two Halves, the one enlightned with So ſhine, the other Shadow'd, and where they part on the Equ nox, is the Hour of the Day in two Places on the Ball.

PROB. VIII. *To make an* Erect South Dial *f Latitude* 51 *Degrees* 30 *Minutes.*

The Operation by the *Globe.*

We may reduce all Verticals to Horizontals, if we elev the Pole to the Complement of the Latitude, which in th Caſe is 38 Degrees 30 Minutes, and bring the *Vernal Colure* the Meridian, and the Index to 12, then turn the Globe We wards, and as each 15th Degree is at the Meridian (or as th Index points out the ſeveral Hours on the Hour-Circle) th *Colure* ſhews in the Horizon the Diſtance of the ſeveral Hou Lines, from the Meridian, as in the following Table.

Comp. Latitude 38°. 30'.		
Hours.	Diſtances from the Meridian.	
12	00°	00'
11 1	09	28
10 2	19	45
9 3	31	54
8 4	47	09
7 5	66	42
6	90	00

Th

he Geometrical Conſtruction, *Plate* 2. *Figure* 5.

1. Draw a Meridian-Line, as EM, for the Hour-Line of 12, oſs it at Right-Angles with the Line NP for the Hour-Line 6, and 6, and where theſe Lines croſs each other (as at O) he Center of the *Dial*.

2. With the Chord of 60 Deg. draw a Semicircle NPQ, and m the Line of Chords take the Hour-Diſtances (as in the egoing Table) from the Meridian, and lay on the Semicle, one Foot of the Compaſs being in the Meridian; o' which Diſtances, from the Center, draw the Hour-nes.

3. For the Style, take 38 Deg. 30 Min. (the Complement of t Latitude) from the Line of Chords; ſet it from Q to R, draw the Line OR for the Cock or Style of our Dial, ich muſt ſtand over 12, and point downwards towards the *h* Pole.

N. B. The *North* Vertical Dial is the ſame with the *South*, on- he Style muſt point upwards, towards the *North* Pole, and Hours 9, 10, 11, 12 at Night, and 1, 2, 3 in the Morning ſt be left out, and 4, 5 in the Morning, and 7, 8 at Night, ſt be drawn through the Center, ſo is our *North* Dial fi-ned.

R O B. IX. *To make an* Erect, Direct Eaſt *or* Weſt-Dial.

Theſe Sorts of Dials may be better demonſtrated than made the Globe, for the Pole being rectified to the Latitude, Index to 12, and the Quadrant of Altitude in the Zenith; he Quadrant be brought about till the graduated Edge there-be exactly *Eaſt* or *Weſt*. and turning the Globe about, the Equinoctial Colure will not cut the Quadrant of Altitude ny particular Degree, but a Part of the Colure will coin- with all the Degrees of the Quadrant at the ſame Time; erefore the Hour-Lines of theſe Planes will make no Angles he Pole, and conſequently muſt be parallel to one another, ich the Globe plainly repreſents, but will not convenient-give the Parallel Diſtance of each from the other, they be- nearer or farther off, according as the Style is proporti-d to the Plane.

The Geometrical Conſtruction.

Let the Plane, upon which we would make an *Eaſt* or *W* *Dial*, be ABCD, Plate 2. Fig. 6.

1. Upon D, if it be an *Eaſt-Dial-Plane*; or upon the Point C if it be a *Weſt-Dial*, with the Radius of the Line of Chor deſcribe an Arch of a Circle GF, then from the Line Chords take 38 Deg. 30 Min. and draw the Line DGE qu through the Plane for the Equinoctial, towards the upper Pa of this Line, as at P; aſſume any Point, and through it dr the Line 6 P 6, perpendicular to the Equinoctial for the Ho Line of Six, alſo towards the lower Part of the ſame Line, aſſume another Point as L, and through it draw the Li 11 C 11, for the Hour of Eleven.

2. With 60 Deg. from the Chords, upon the Point C, deſcribe a ſmall Arch of a Circle as HK, and upon it ſet 15 grees, or one Hour's Diſtance from H to K, and draw the Li CKM. cutting the Hour-Line of 6 in M.

Upon M as a Center, with 60 Deg. from the Chords, deſcribe an Arch of a Circle NO, which divide into five equ Parts in the Points OOO. *&c.* Lay a Ruler upon M, and e of theſe Points. and the Ruler will cut the Equinoctial Li DE in the Points ***, through which Points, if we dr right Lines parallel to the Hour-Line of 6, they will be Hour-Lines of 7, 8, 9 and 10, the Hour-Lines of 6 and 11 ing drawn before.

For the Hour-Lines of 4 and 5 in the Morning, they re the ſame Diſtance from ſix, as do the Hours 8 and 7.

The Stile muſt ſtand upon the Hour-Line of 6, and be Heighth equal to the Length of the Line MP, and may be ther a Pin or Wire, or a Plate of Braſs. or Iron.

An Erect, Direct *Weſt-Dial* is the ſame in all reſpects with Erect, Direct *Eaſt-Dial*, only as the *Eaſt* ſhews the Foreno Hours, the *Weſt* ſhews the Afternoon Hours, for that which in the *Eaſt-Dial* is 10, the *Weſt-Dial* muſt be 2; and 9 in the *Dial* muſt be 3 in *Weſt*.

Prob. X. *Of Erect* Declining Planes.

The Upright or Erect Planes that we have hitherto trea of. are ſuch as do directly behold the four Cardinal Points the Horizon, all other Upright Planes are ſaid to decline, a

eir Declination is counted from the *North* or *South*, towards e *East* or *West*; thus to make an Erect *Dial* for 51 Deg. 30 in. *North*, the Plane declining from the *North* towards the *East*, Degrees: Elevate the Pole to the given Latitude, fix the uadrant of Altitude to the Zenith, and number the Decli- tion of the Plane upon the Horizon from the *North*, (or *uth* Point thereof according as the Plane declines) namely, Deg. and to that Point of the Horizon bring the Quadrant Altitude, and there fix it, then bring the Vernal Colure the Meridian, and the Index of the Hour-Circle to the up- rmoſt Figure of 12. in the Hour-Circle; then turn the obe Eaſtwards, till the Index points to all the Hours before oon; and examine in what Number of Degrees from the nith the Colure cuts the Quadrant of Altitude, when the dex points to each Hour, or when each 15 Degrees of the uator paſſes the Meridian, for the Degrees of the Quadrant, mbred from the Zenith, cut off by the Colure, are the ſtances of the Forenoon Hour-Lines, as are expreſſed in the llowing Table.

urs rom oon.	Hours diſt. on the Plane
	° ′
11	9 43
10	19 00
9	25 57
8	35 10
7	45 56
6	60 15
5	79 43

There is this Difference between *Direct* and *Declining Dials*, that the Hour-Diſtances for the Afternoon on *Declining Dials*, are not the ſame with the Hour-Diſtances for the Forenoon, becauſe the Sun remains longer on that Side of the Plane, which it de- clines to, than it doth on the contrary Side; therefore, there will be a greater Number of Hour-Lines upon it. and by Conſequence the Diſtances of the Hour- Lines leſs than on the contrary Side of the Plane; therefore, for finding the Afternoon Hour-Diſtances, turn about the Quadrant of Altitude upon the Zenith-Point, till the lower End of it comes to the Degree of the Horizon, oppoſite to that Degree of clination, the Quadrant of Altitude was placed at, when Diſtance of the Forenoon Hour-Lines was found, *viz.* to Degrees, counted from the *South* towards the *Weſt*, and bring Vernal Colure again to the Meridian. and the Index to 12; n turning the Globe Weſtwards, as the Index points to the eral Hours, or at each 15 Degrees of the Equator paſſing Meridian, the Colure will cut the Quadrant of Altitude the Afternoon Hour-Diſtances, numbred from the Zenith, are expreſſed in the following Table.

Hours

Hours from Noon.	Hours dist. on the Plane
1	11 20
2	26 47
3	49 20
4	75 52

It is to be observed, that this Plane is capable of receiving no more Hour-Lines after Noon, than 4, for when the Colure goes off the Quadrant of Altitude, the Sun goes off these Kind of Planes.

And to find the Distance of the Substilar-Line from the 12 a-Clock-Line, and the Elevation of the Stile about the Plane, which are two Requisites always to be found in upright declining Planes, bring the Colure to the Number of Degrees of the Plane's Declination, counted in the *Horizon*, from the *South* Point towards the *East*, and the Quadrant of Altitude to the Degrees of the Plane's Declination on the *Horizon*, from the *North* towards the *East*, so shall the Quadrant of Altitude and the Colure, cut each other at Right-Angles, and the Number of Degrees comprehended between the Colure and Zenith in the Quadrant of Altitude, shall be the Number of Degrees between the Substilar-Line and the 12 a-Clock-Line, which, in this Example, is 19 Deg. 45 Min. and the Number of Degrees comprehended between the Quadrant of Altitude and the Pole, counted on the Colure, shall be the Number of Degrees that the Stile is to be elevated above the Plane, which in this Example, is 33 Deg. 40 Min.

The Geometrical Construction, *as in* Plate 2. Fig. 7.

Draw on our Plane an Horizontal Line, as CD, and with the Chord of 60 Degrees describe a Semicircle DBC, which divide into two equal Parts, and draw the Line AB, which will be the Hour of 12, then, from a Line of Chords, take the several Hour-Distances from the Meridian, and lay on the Semicircle from B to C and D, drawing Lines from the Center A, through those Divisions, so shall all the Hour-Lines be represented on the Plane; then to represent the Substilar-Line on that Plane, from the Line of Chords, take 19 Degrees 45 Minutes, the Distance of the Substilar-Line from the 12 a-Clock-Line, and on the Semicircle from the 12 a-Clock-Line at B set it off to x, on the contrary Side to the Declination of the Plane, which, in this Case, must be in the *West* Side, and from the Center A draw A x, which shall represent the Substilar-Line; and from the Substilar-Line, lay off 33 De-

3 Deg. 40 Min. the Elevation of the Stile above the Plane, n the Circle from x to y, then draw the Line A y for the tile, or *Gnomon*; and let fall the Perpendicular a b upon the ubstile, ſo we have a Triangle, which erected perpendicular pon the Subſtile A x, the Stile A y ſhall be parallel to the xis of the World, and caſt a Shadow upon the Hour of the ay.

Here we may obſerve, that in *Declining Dials*, the Stile doth ot ſtand at the ſame Elevation above the Plane, that it doth *Erect Direct Dials*, neither doth it ſtand over the 12 a-Clock- ne, but on ſome Part of that Quarter towards which the eclination of the Plane is.

Thus we have finiſh'd our Dial, and in ſo doing, we have, this one, made four Dials, *viz.*

			Deg.	Min.
A	*North* declining *Eaſt* *North* declining *Weſt* *South* declining *Eaſt* *South* declining *Weſt*		63	00

Only placing the Number of the Hours, and the Stile reſpec- ely upon each Plane: For in the *South-Weſt* Plane, the Stile nds upon the Hour-Line of 2 in the Afternoon; in the *h Eaſt*, declining as much, it will ſtand upon the Hour- e of 10 before Noon. And ſo all the Morning-Hours of *Weſt-Decliner*, will be the Afternoon-Hours of the *Eaſt-De- r*, and the Afternoon-Hours of the *Weſt-Decliner* will be the rning-Hours of the *Eaſt-Decliner*; and the *South-Eaſt-Decliner* produce the *North-Weſt-Decliner*, and the *South-Weſt Decliner*, *North-Eaſt-Decliner*, by only extending the Hour-Lines, Stile Subſtile, quite thro' the Center.

CHAP. XI. *Of Direct* South *Reclining DIALS.*

eclining Planes are thoſe that cut the Horizon at Oblique gles, reclining from the Zenith, or inclining to the Hori- , and are either direct *North*, *South*, *Eaſt*, or *Weſt* reclining, eclining from the *North*, *Weſt*, &c. and ſo are call'd *Declining ning Planes*.

South-Plane may ſo recline, that the Reclination thereof be either

than
l to
e than } the Complement of the Latitude.

Now,

Now, to reduce any of these Planes to a new Latitude, wher they may become Horizontal-Planes.

1. If the Reclination of the Plane be less than the Compl ment of the known Latitude, subtract the Plane's Reclinatio from the Complement of the Latitude, and the Remainde shall be a new Latitude, where the Reclining Plane shall b an Horizontal Plane; and, in this Case, the *South-Pole*, in *Nor Latitude*, is always elevated.

2. If the Reclination be equal to the Complement of t Latitude: In that Case the Plane lies in the Axis of the Wor and hath no *Pole* elevated above it.

3. If the Reclination of the Plane be more than the Co plement of the Latitude, subtract the Complement of La tude from the Plane's Reclination, and the Remainder sha be the new Latitude; and in this Case the *North-Pole*, in *Nor Latitudes*, is always elevated.

In the first of these three Varieties: If a *South-Plane* in t Latitude of 51 Deg. 30 Min. recline 20 Degrees, which is l than the Complement of the given Latitude; therefore Reclination being subtracted from it, leaves 18 Deg. 30 M for the new Latitude: Wherefore, if we rectify the Globe 18 Deg. 30 Min. of Latitude, and find the Distances of Hour-Lines from the Meridian, for a Horizontal-Dial in t Latitude, that Dial shall serve for a *South-Reclining* 20 Deg. in Latitude of 51 Deg. 30 Min. and the Heighth of the Stile bove the 12 Hour-Line, or Substile, will be equal to the n Latitude, namely 18 Degrees 30 Minutes.

In the second Case, when the *South-Reclination* and Com ment of the *North-Latitude* are equal, the Dial is to be made all Respects like an *East* or *West-Dial*; only that which in *East* or *West-Dial* is the Six o'Clock Hour-Line, must in t *Dials* be the Hour-Line of 12, *&c.*

In the third Case, suppose a *South-Plane* to recline from Zenith 60 Deg. in the Latitude of 51 Deg. 30 Min. the C plement of which subtracted from 60 Deg. leaves 21 Deg Min. for the new Latitude, and find the Hour-Distances the Horizontal-Dial in that Latitude, which Hour-Distan will serve for a *South-Dial* reclining from the Zenith 60 Deg in the Latitude of 51 Deg. 30 Min. and the Stile of the must be elevated above the Substile, or Hour-Line of 21 Deg. 30 Min. equal to the new Latitude, and p upwards towards the *North-Pole*, as the Stiles of all *Planes* do, which recline more than the Complement of the titude; thus the Hour-Distance of all *South-Reclining-Dials*,

be found by the Globe, by referring ſuch reclining Planes to Latitude, where they may become Horizontal-Planes.

Prob. XII. *Of* North-*Reclining* DIALS.

There are three Varieties of *North-Decliners*, as there are of *South-Recliners*, for the Reclination may be either

Leſs than
Equal to
More than
} the Latitude of the Place.

And to refer theſe to a new Latitude, where they will be Horizontal-Planes, we muſt obſerve,

1. If the Reclination of the Plane be leſs than the Latitude, add the Complement of the Latitude to the Plane's Reclination, and the Sum will be the new Latitude. Thus, let a *North-Plane* in the Latitude of 51 Deg. 30 Min. recline from the Zenith 20 Deg. add 20 Degrees, the Plane's Reclination, to 38 Deg. 30 Min. the Complement of the Latitude, the Sum will be 58 Deg. 30 Min. which is the new Latitude. Wherefore, if we rectify the Globe to 58 Deg. 30 Min. and find the Hour-Diſtances of a Horizontal-Dial in that Latitude, thoſe Diſtances will ſerve for a *North-Plane* reclining 20 Deg. in the Latitude of 51 Deg. 30 Min. *North*, and the Stile muſt be elevated above the Subſtile, or Hour-Line of 12, 58 Deg. 30 Min. equal to the new Latitude.

In the Second of theſe Varieties, where the Plane of the Meridian reclines, ſo as to cut the Meridian juſt at the Interſection of the Meridian with the Equator, the Plane it ſelf lying in the Equinoctial-Circle, and the Poles thereof in the Poles of the World; it is call'd a Polar-Plane. Wherefore rectify the Globe to 90 Deg. of Latitude, ſo ſhall the Poles be in the Zenith and Nadir, and the Equator in the Horizon, then turn the Globe about till 15 Degrees of the Equinoctial-Colure have paſſed the Meridian, and it will reſt at 15 Deg. of the Horizon, which is the firſt Hour's Diſtance from 12. and in theſe Planes the Degrees of the Equator and Horizon being the ſame, the Hour-Lines are equally removed from one another; wherefore, if a Circle be deſcribed and divided into 24 equal Parts, Lines being drawn from the Center to each Diviſion, and a Wire perpendicularly placed in the Center, the Dial is finiſhed.

In the third Caſe, when the Plane reclines more than the Latitude, and cuts the Meridian between the Equator and the

Horizon; add the Reclination to the Complement of the Latitude, which Sum (if it don't exceed 90 Deg.) is a new Latitude, but if it exceeds 90 Deg. ſubtract that Sum from 180 Deg. and the Remainder will be a new Latitude; for which new Latitude rectify the Globe, and make an Horizontal-Dial, elevate the Stile above the 12 a-Clock Hour-Line equal to the new Latitude, and the Dial is finiſhed.

PROB. XIII. *Of Declining Reclining or Inclining PLANES.*

Such Planes as do not behold the *Eaſt*, *Weſt*, *North*, or *South* Points of the Horizon directly, are called *Decliners*, and if they are not perpendicular to the Horizon, they both decline and incline, therefore they are called *Declining Inclining Planes*; for the making of theſe kind of Dials, let us ſuppoſe a Plane in the Latitude of 51 Deg. 30 Min. to decline from the *North* Part of the Meridian towards the *Weſt* 72 Degrees, and alſo to recline from the Zenith 26 Deg. 34 Min.

1. Elevate the Globe to the given Latitude 51 Deg. 30 Min. fix the Quadrant of Altitude in the Zenith, the Hour-Index to 12, and the Equinoctial-Colure to the Meridian.

2. The Declination of the Plane being 72 Deg. Weſtward, count upon the Horizon 20 Deg. the Complement of the Declination, from the *South* Part of the Meridian Weſtward, and from the *North* Part of the Meridian Eaſtward, and to theſe two Points on the Horizon bring the Ends of a narrow Plate of thin Braſs, containing a complete Semicircle, divided into Degrees, beginning the Diviſions at the Middle, and numbring them both Ways, and there fix it; then bring the Quadrant of Altitude to 20 Degrees on the Horizon, counted from the *Eaſt-Southward*. Now becauſe the Plane reclines 26 Deg. 34 Min. count thoſe Degrees downwards from the Zenith, and to that Point bring the thin Plate of Braſs repreſenting the Plane, and there fix it; ſo is the Globe prepared for the making of this Dial; and for the Hour-diſtances, turn the Globe Eaſtward, till 15 Degrees of the Equator have paſs'd the Meridian, and upon the Plane, or Plate of Braſs, we ſhall find the Colure cut the Semicircle, counted from the Middle of it at 26 Deg. 3 Min. and by turning ſtill Eaſtward, and obſerving where the Colure cuts the Semicircle at each 15 Degrees of the Equator, paſſing the Meridian, we ſhall find the Forenoon Hour-Diſtances, as in the following Table; and the Colure being again brought to the Meridian, and the Globe turned

turned to the *West*, at each 15 Degrees of the Equator, croſſing the Meridian, the Colure will cut the Semicircle in the Afternoon Hour-Diſtances, as in the following *Table*.

	Hours.		Deg.	Min.
Forenoon	12		00	00
	1	11	26	3
	2	10	44	30
	3	9	57	47
	4	8	67	53
	5	7	76	12
	Subſtile.		Subſtile.	
Afternoon	6	6	84	15
	7	5	87	38
	8	4	78	25
	9	3	66	48
	10	2	50	46
	11	1	28	4

Now beſides theſe Hour-Diſtances, we muſt find four Things more, preparatory to the Geometrical Conſtruction of theſe *Dials*.

1. *The Arch of the Plane, or the Diſtance between the Meridian and Horizon*, which may be found thus:

Take, with the Compaſſes, the Diſtance upon the Plane, from the Interſection of the Plane with the Horizon, to the Interſection of the Plane with the Meridian, which Number of Degrees, namely, 36, is the Diſtance required.

2. *The Arch of the Meridian between the Plane and Zenith*, thus: The Degrees of the Meridian intercepted between the Plane and Zenith, *viz.* 58 Deg. is the Arch required.

3. *The Heighth of the Pole and Stile above the Plane.*

To find which, continue the Quadrant of Altitude from the Zenith, below the Horizon, ſo much as is the Reclination of the Plane, 26 Deg. 34 Min. and mark that Point. Then, a thin Plate of Braſs (if the Quadrant of Altitude be too ſhort) divided and extended from the *North-Pole* towards the *South-Pole*, and paſſing through the *Pole* of the *Plane*, which is the Point before found, mark where the Plate cutteth the Plane, and the Number of Degrees upon the Plate contain'd between the

Pole and the Plane, which in this Case will be 31 Deg. 28 Min. is the Heighth of the Pole above the Plane or Substile.

4. *The Distance of the Substile from the Meridian.*

And that is, the Number of Degrees of the Plate representing the Plane, which are contained between the Plate, which came from the Pole of the World to the Pole of the Plane and the Intersection of the Plane with the Meridian, which in this Example will be 82 Deg. 4 Min. as appears by the following Table.

	Deg.	Min.
North Declining —— —— —— —— ——	72	00
Reclining —— —— —— —— ——	26	34
Distance between the Meridian and Horizon ——	36	00
Distance between the Plane and Zenith —— ——	58	36
Heighth of the Pole above the Plane —— ——	31	28
Distance of the Substile and Meridian ——	82	4

The Geometrical Construction of this DIAL

Plate 2. Figure 8.

1. Upon the Plane, on which we intend to describe the Dial, draw a Horizontal-Line, as AB, and another Perpendicular to it, as DG, for the Vertical-Line of the Plane, cutting the former AB in the Point C, which Point C makes the Center of the Dial.

2. Upon the Center C, with 60 Deg. of a Line of Chords describe a Circle, as AFBG, then take 36 Deg. (*the Distance of the Meridian from the Horizon*) and set it from A to 12 downwards, and from B to 12 upwards, and draw the Line 12C 12, for the Hour-Line of 12.

3. Take 82 Deg. 4 Min. (*the Distance of the Substile from the Meridian*) and set them from 12 upwards to G on the Left-Hand, and downwards from 12 to G on the Right-Hand, drawing the Line GCG, through the Center, for the Substilar-Line of both Dials;

ials: And the Heighth of the Pole or Stile above the Plane eing 31 Deg. 28 Min. ſet thoſe Degrees from G to H, both bove and below, and draw the Line HCH quite thro' the enter for the Axis or Stiles of both Dials.

8. In the Table of Hour-Diſtances aforeſaid, find e firſt Hour's Diſtance from 12 which is 26 Deg. 3 Min. t that Diſtance upon the Circle from 12 upwards to 1, and om 12 (on the other ſide) downwards to 11, and draw the nes G 1, and C 11; for the Hour-Lines of 11 and 1 a-Clock, hich will both make one ſtrait Line.

Do thus with all the Hours in the Table, till we come up- the Subſtile, and then (beginning at the Bottom of the ble.)

. Take 28 Deg. 4 Min. and ſet from 12 on the Right-Hand wnwards to 11, and from 12 on the Left-Hand upwards to draw the Line C 11 in the *North-Reclining-Plane*, for the Sun ll never ſhine upon the *South-Reclining-Plane* at 1, otherways ſhould have drawn it thro' the Center as we did before.

Laſtly, Erect the Stile perpendicular to the Subſtile, making an gle therewith equal to the Elevation thereof; namely, 31 g. 28 Min. and the Dials are finiſhed. And in making of ſe we have made two others alſo; *viz.* A *North-Declining* 72 g. Eaſtward, and Inclining 26 Deg. 34 Min. and a *South-De-* ng Weſtward 72 Deg. and Inclining, as the other; all which one, and may eaſily be apprehended by any Perſon that un- ſtands the former Problems.

OB. XIV. *A General Rule to know which* Pole, *whether the* North *or the* South, *is to be levated over any* Plane.

he Stile of every Dial reſpecteth (or rather lieth parallel) the Axis of the World, and always pointeth upwards or nwards, to one of the Poles. Now, when we have drawn our (though truly) we may be to ſeek, whether it be the *North uth-Pole* that muſt be elevated; wherefore to avoid any ke, and to know which Pole is to be elevated, obſerve General Rule.

Upon

Upon all Upright-Planes, whether Direct or Declining, upon the { South / North } { Side the } { South / North } Pole.

Upon all { East and West } { Recliners / Incliners } the { North / South } Pole.

Upon all { North / South } { Recliners / Incliners } { whether Direct or Declining } the { North / South } Pole.

Upon all { South Recliners / North Incliners } { whether Direct or Declining. If the Plane pass between the } { Zenith / Nadir / Horizon } { and the Pole, the } { South / North / South } Pole.

This Rule being duly observed, there will be no Difficu
to find which is elevated.

A TA

A TABLE of Meridional-Angles: Or, Angles which the Hour-Lines make with the Meridian, both in Horizontal and Erect *South-Dials* in all Latitudes.

Hor. Dial. Lat.	XI. I. d.	m.	X. II. d.	m.	IX. III. d.	m.	VIII. IV. d.	m.	VII. V. d.	m.	VI.	South Dial La.
0	0	0	0	0	0	0	0	0	0	0	90 Degrees throughout.	90
1	0	16	0	34	1	0	1	44	3	44		89
2	0	32	1	9	2	0	3	27	7	25		88
3	0	48	1	44	3	0	5	11	11	3		87
4	1	5	2	19	4	0	6	54	14	36		86
5	1	20	2	52	4	58	8	35	18	1		85
6	1	36	3	27	5	58	10	16	21	19		84
7	1	52	4	3	6	57	11	55	24	27		83
8	2	8	4	37	7	55	13	33	27	23		82
9	2	23	5	9	8	54	15	10	30	17		81
10	2	40	5	43	9	55	16	44	32	54		80
11	2	55	6	17	10	48	18	17	35	27		79
12	3	11	6	51	11	45	19	40	37	49		78
13	3	27	7	24	12	41	21	17	40	1		77
14	3	43	7	57	13	36	22	44	42	4		76
15	3	58	8	30	14	31	24	0	44	0		75
16	4	13	9	2	15	25	25	31	45	49		74
17	4	29	9	35	16	16	26	52	47	26		73
18	4	44	10	8	17	10	28	9	49	4		72
19	4	59	10	39	18	2	29	25	50	33		71
20	5	14	11	10	18	53	30	39	51	55		70
21	5	29	11	41	19	44	31	50	53	9		69
22	5	44	12	12	20	32	32	58	54	21		68
23	5	59	12	43	21	20	34	5	55	30		67
24	6	13	13	13	22	8	35	10	56	37		66
25	6	28	13	43	22	55	36	12	57	34		65
26	6	42	14	12	23	40	37	13	58	34		64

A TABLE of Meridional-Angles, &c.

Ho. Dial La.	XI. I. d.	m.	X. II. d.	m.	IX. III. d.	m.	VIII. IV. d.	m.	VII. V. d.	m.	VI.	&. Dial La.
27	6	56	14	41	24	25	38	11	59	27	90 Degrees throughout.	63
28	7	10	15	19	25	9	39	7	60	17		62
29	7	24	15	40	25	52	40	2	61	4		61
30	7	38	16	6	26	33	40	54	61	49		60
31	7	50	16	34	27	15	41	44	62	30		59
32	8	5	17	1	27	55	42	30	63	11		58
33	8	19	17	27	28	34	43	20	63	49		57
34	8	31	17	54	29	13	44	5	64	24		56
35	8	44	18	20	29	50	44	49	64	58		55
36	8	57	18	49	30	27	45	31	65	30		54
37	9	10	19	9	31	2	46	12	66	10		53
38	9	22	19	34	31	37	46	50	66	29		52
39	9	34	19	58	32	11	47	28	66	56		51
40	9	45	20	21	32	44	48	7	67	21		50
41	9	57	20	44	33	16	48	39	67	47		49
42	10	10	21	7	33	46	49	12	68	11		48
43	10	22	21	29	34	18	49	44	68	33		47
44	10	32	21	51	34	47	50	10	68	54		46
45	10	44	22	12	35	17	50	46	69	15		45
46	10	54	22	33	35	44	51	15	69	35		44
47	11	5	22	53	36	11	51	42	69	53		43
48	11	17	23	13	36	37	52	9	70	11		42
49	11	25	23	33	37	3	52	35	70	28		41
50	11	35	23	52	37	28	53	0	70	43		40
51	11	45	24	9	37	52	53	24	70	59		39
52	11	55	24	27	38	15	53	46	71	13		38
53	12	5	24	43	38	37	54	12	71	28		37
54	12	13	25	2	38	58	54	29	71	41		36
55	12	22	25	18	39	19	54	49	71	54		35
56	12	32	25	34	39	40	55	9	72	5		34
57	12	40	25	50	39	50	55	28	72	17		33
58	12	48	26	5	40	1	55	45	72	28		32

A TABLE of Meridional-Angles, &c.

Hor. Dial Lat.	XI. I.		X. II.		IX. III.		VIII. IV.		VII. V.		VI.	South Dial Lat.
	l.	m.	d.	m.	d.	m.	d.	m	l.	m		
59	12	56	26	20	40	36	56	3	72	38		31
60	13	4	26	34	40	54	56	15	72	48		30
61	13	11	26	47	41	10	56	34	72	58		29
62	13	19	27	1	41	31	56	45	73	7		28
63	13	26	27	13	41	42	57	3	73	15		27
64	13	32	27	25	41	57	57	17	73	24		26
65	13	36	27	37	42	15	57	30	73	32		25
66	13	46	27	49	42	25	57	43	73	39		24
67	13	51	27	59	42	38	57	54	73	46		23
68	13	57	27	9	42	50	58	5	73	53		22
69	14	3	28	19	43	2	58	16	73	59		21
70	14	7	28	25	43	13	58	26	74	5		20
71	14	13	28	37	43	18	58	35	74	11		19
72	14	18	28	46	43	24	58	44	74	16		18
73	14	22	28	54	43	36	58	52	74	20		17
74	14	27	29	2	43	52	59	0	74	25		16
75	14	30	29	7	44	0	59	7	74	30		15
76	14	33	29	15	44	8	59	15	74	34		14
77	14	37	29	21	44	14	59	22	74	37		13
78	14	41	29	27	44	22	59	27	74	40		12
79	14	44	29	32	44	28	59	32	74	44		11
80	14	47	29	37	44	34	59	37	74	47		10
81	14	49	29	41	44	37	59	40	74	49		9
82	14	51	29	45	44	40	59	44	74	51		8
83	14	53	29	49	44	44	59	47	74	53		7
84	14	55	29	22	44	48	59	51	74	55		6
85	14	56	29	54	44	53	59	54	74	57		5
86	14	57	29	55	44	55	59	55	74	58		4
87	14	58	29	56	44	56	59	56	74	58		3
88	14	55	29	57	44	57	59	58	74	59		2
89	14	55	29	58	44	58	59	59	74	59		1
90	15	0	30	0	45	0	60	0	75	0		0

90 Degrees throughout.

PROB. XV. *The Day of the Month, and Ho of the Day, according to our Way of reckoning* England, *being given, to find thereby the* Baby nic, Italic, *and the* Planetary *or* Judaical Ho

1. To find the *Babylonic Hour* (which is the Number of Ho from Sun-rising.) Having found the Time of Sun-rising in given Place, the Difference betwixt this and the Hour giv is the *Babylonic* Hour.

2. To find the *Italic Hour*, which is the Number of Ho from Sun-setting.) Subtract the Hour of Sun-setting, fr the given Hour, and the Remainder will be the *Italic Hour* quired.

3. To find the *Planetary* or *Jewish Hour*, (which is $\frac{1}{12}$ Part of Artificial Day.) Find how many Hours the Day consists of; t say, as the Number of Hours the Day consists of, is to 12 Ho so is the Hour since Sun-rising, to the *Planetary* or *Judaical* required.

Thus, If the Sun rises at 4 o'Clock, (consequently it se 8) and the Hour given be 5 in the Evening, the *Babylonic* will be the 13*th*; the *Italic* the 21*st*; and the *Planetary* or *Hour* will be Nine and three Quarters.

The Converse being given, the Hour of the Day, accor to our Way of reckoning in *England* may be easily found.

TRIGON

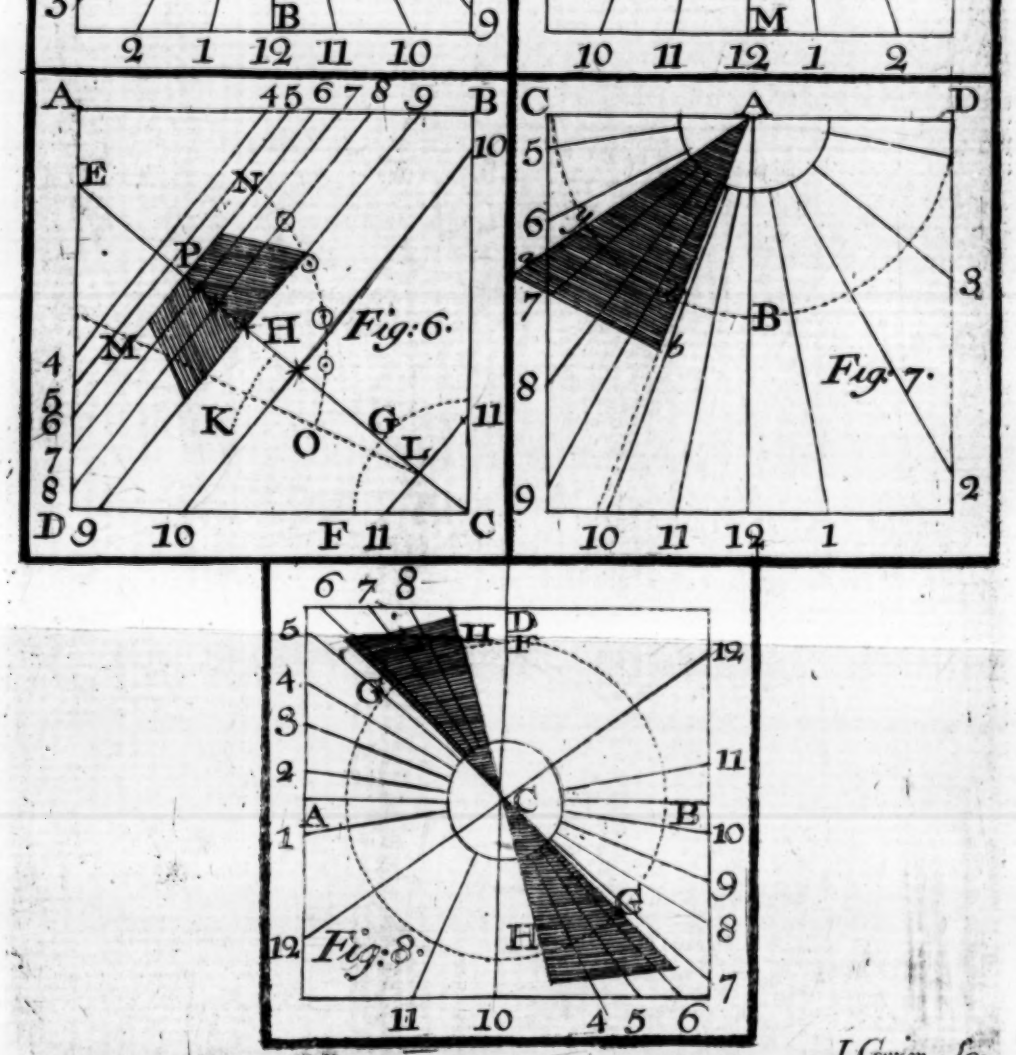
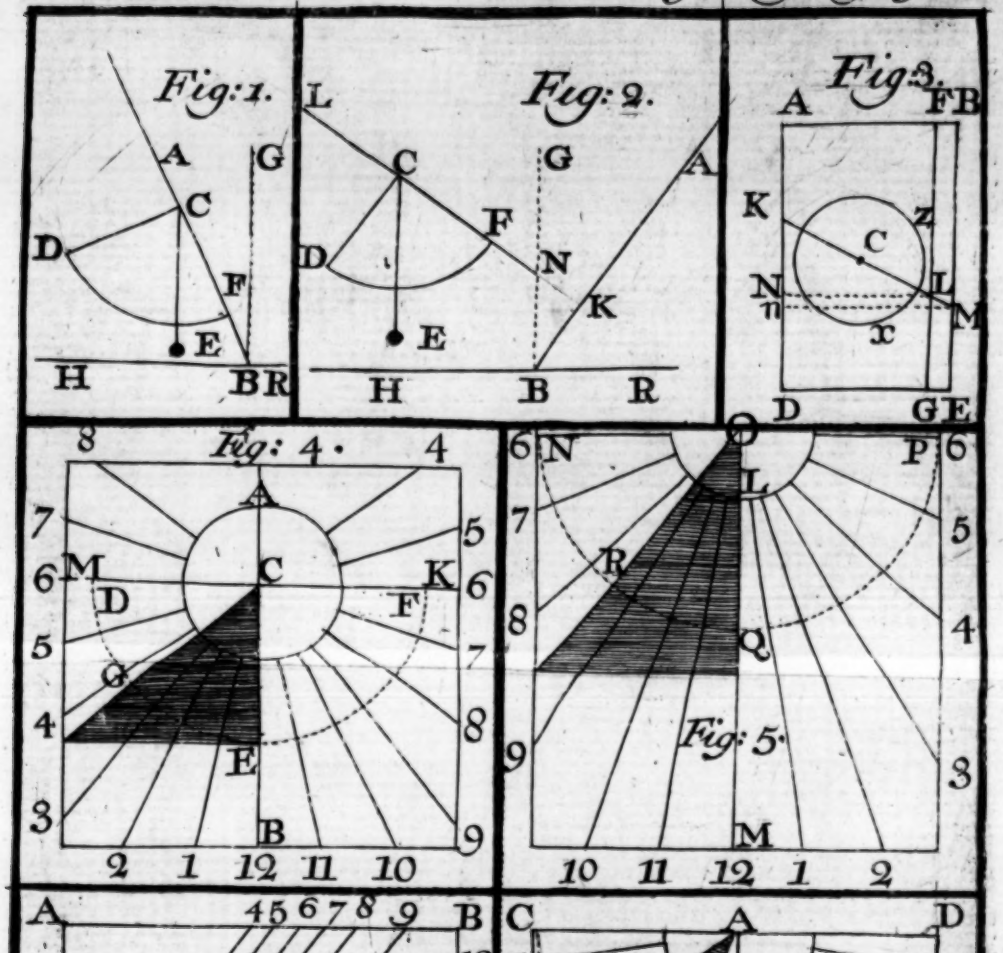

A
B
C
D
E
F
G
H
K
L
M
N
O
P
Fig: 6.
Fig: 7.
Fig: 8.
J Cowin Sc.

Plate II. *fronting Page 98*



TRIGONOMETRICAL PROBLEMS, Solv'd by the GLOBES.

SECT. V.

Of the Solution of SPHERICAL-TRIANGLES upon the GLOBE.

SPHERICAL-TRIANGLES are best represented by the *Circles* on, and those *appendant* to the *Globes*: The *Globe* being the *Original* from whence all *Spherical-Trigonometry* proceeds, and upon which the Sides and Angles of all *Spherical-Triangles* are most naturally represented and most expeditiously measured.

Definition I. A *Spheric-Triangle* is bounded by the *Arks* of three great *Circles* of the *Sphere*, or *Globe*, each *Ark* being less than a semicircle, or 180 Degrees.

Def. II. A *Spheric-Angle* is the same with the Inclination of the *Planes* of those two *Circles* which constitute the *Angle*; and

if from the Point of any *Spheric-Angle* as a *Pole*, we deſcribe a *Circle* at the Diſtance of 90 Degrees from that Point, the Arc of this *Circle* intercepted between the Legs of the Angle is the Meaſure of it.

Def. III. When a *Spherical-Angle* has one or more Right-Angles; that is, contains 90 Degrees, it is call'd a Right-angled *Spherical-Triangle*: If all its Angles be acute, that is, each of them leſs than 90 Degrees, it is call'd an *Acute-Angled Triangle*; and if all its Angles be *Obtuſe*, each exceeding 90 Degrees, or if ſome of them be *Obtuſe* and ſome *Acute*, it is called an *Obtuſe-Angled Spherical-Triangle.*

Def. IV. The Complement of a Side or Angle to a Quadrant or 90 Degrees, is ſo much as that Side or Angle wants of 90 Degrees; and their Complement to a Semicircle, is ſo much as that Side or Angle wants of 180 Degrees.

Def. V. If two great *Circles* of the *Sphere* paſs through each other's *Poles*, thoſe two great *Circles* interſect each other at Right Angles; but if they interſect each other, and do not paſs through each other's *Poles*, thoſe two *Circles* ſhall interſect each other at Oblique-Angles.

Def. VI. If a *Spherical-Triangle* hath three Right-Angles, the three Sides of that Triangle ſhall be all Quadrants, as in a Parallel-Sphere, the Braſs-Meridian cutting the Horizon in *North* and *South* at Right-Angles, the Equinoctial Colure cutting the Horizon in the *Eaſt* and *Weſt*-Points at Right-Angles; and the Meridian and Colure interſecting each other in the Poles of the World at Right-Angles; do conſtitute a Spherical-Triangle with three Right-Angles; and the three Sides of this Triangle for this Reaſon, ſhall be all of them Quadrants.

Def. VII. The Sides of Spherical-Triangles are of the ſame Affection or Kind with their oppoſite Angles.

Def. VIII. All great *Circles* muſt cut each other in two equal Parts, becauſe their common Interſection is a Diameter of the Sphere, and conſequently the two Points of Interſection are at the Diſtance of a Semicircle from each other.

Def. IX. The oppoſite Angles at the Interſection of two Circles, are always equal, becauſe the ſame Plane conſtitutes both Angles.

PRO

ROB. I. *To Project the* Sphere *for the Latitude* 51 *Degrees* 30 *Minutes* North, *Geometrically.*

Quarter the Circle, which represents the Solstitial-Colure or ridian, with Z N the Prime-Vertical, and H O the Horizon: en set the Chord of the Latitude 51 Deg. 30 Min. from H P, the Pole: from Z the Zenith to Æ the Equinoctial from o S, and from N to Q, and draw Æ Q the Equinoctial, d P S the Equinoctial-Colure, from Æ and Q on both Sides, off the Chord of 23½ Degrees for the Tropics ♋ and ♑, draw ♋ X ♎ the Ecliptic; lay a Rule from Æ to ♋, ich cuts P S in L, then thro' the three Points ♋ L ♋, w the Tropic of ♋, which suppose the apparent Course of Sun for that Day, which cuts the Horizon at ☉, thro' the ee Points P ☉ S draw the Meridian P ☉ S. which forms first and third Triangles shaded, and at 6 a Clock, the ☉ ears at L, thro' Z L N three Points, draw the Vertical EN, which forms the fourth shaded Triangle X L E. Again, pose the ☉ at M, thro' the three Points Z M N, draw the muth Z M N, and draw thro' P M S the Meridian P M S, s is formed both the second and fifth shaded Triangles z, and P Z M.

PROB. II.

n the Right-Angled Spherical-Triangle H ☉ P, Plate 3. ure 1. Right-angled at H are

en { P H, the Latitude 51 Deg. 30 Min.
{ P ☉, the Sun's Distance from the Pole 69 Deg. 30 Min.

quired { H ☉, the Complement of the Sun's Amplitude.
{ H P ☉, the Hour of the Sun's Rising, accounted from Midnight.
{ P ☉ H. the Angle of the Sun's Position, which the Horizon makes with the Meridian.

To represent this Triangle *on the* Globe.

levate the Pole to the given Latitude, and turn the Globe ut till 69½ Degrees of the Equinoctial-Colure counted from Pole, be at the Horizon, so will the Triangle be perfectly described

deſcribed by an Arch of the Braſs Meridian, an Arch of t Horizon, and an Arch of the Colure.

The Complement of the Sun's Amplitude, H ⊙, is numbe on the Horizon, from the Colure to the *North*-Point of t Horizon, and in this Caſe is 57 Deg. 34 Min.

For the Angle H P ⊙, count the Degrees of the Equinocti which are contained between the Colure and the *North*-Side the Braſs Meridian, which Degrees reduced to Time, i. e. Degrees 45 Minutes are equal to 4 Hours 11 Minutes, the Ho from Midnight, the Time of Sun-riſe, and half the Length the Night, which ſubduct from 12, reſts 7 Hours 49 Minu the Time of Sun-ſet, and half the Length of the Day.

For the Angle P ⊙ H, number on the Colure, and alſo the Horizon, the Sides that include the Angle 90 Degrees fr the Angular-Point, and the Diſtance between thoſe two Poi where Reckoning ends, meaſured by the Quadrant of Altitu or by Compaſſes, contains 56 Degrees 39 Minutes, the An of the Sun's Poſition.

Prob. III.

In the Right-angled Spherical-Triangle, X y z Right-an at y, Plate 3. Figure 2.

Given { X z, the Sun's Diſtance from ♈ 72 Degrees.
y X z, the Sun's greateſt Declination 23 Deg. 29 Min.

Required { z y, the Sun's preſent Declination.
X y, the Sun's Right-Aſcenſion.
y z X, the Sun's Poſition, or the Angle that the ridian makes with the Ecliptic.

To repreſent this Triangle *on the* Globe.

Bring the Sun's Place, which is ♊ 12 Deg. to the Br Meridian, and fix the Globe in that Poſition, and the Tri will be repreſented by an Arch of the Equinoctial, an Arc the Ecliptic, and an Arch of the Brazen Meridian.

The Sun's preſent Declination X y 22 Deg. 16 Min. is ſured on the Brazen Meridian, from the Equinoctial to Sun's Place, and is *North*, becauſe betwixt the Equinoctial *North-Pole*.

The Sun's Right-Aſcenſion X y, is meaſured on the Equ tial 70½ Deg. from ♈, to the Braſs Meridian.

And for the Measure of the Angle y z X, number 90 Deg the Meridian from the Sun's Place, and 90 Deg. on the E-ptic from the Sun's Place, so shall the Distance between se two Points, measured by the Quadrant of Altitude, con-n for the Angle y z X, 82 Deg. 20 Min.

Prob. IV.

n the Right-angled Spherical-Triangle A ⊙ B, Right-angled B, Plate 3. Fig. 3.

ven { ⊙ A B, the Complement of Latitude 38 Deg. 30 Min.
{ B ⊙, the Sun's Declination 20 Deg. 30 Min. *North*.

uired { A ⊙, the Sun's Amplitude.
{ A B, the Ascensional-Difference.
{ A ⊙ B, the Sun's Position at Rising.

To represent this Triangle *on the* Globe.

epress the Equinoctial below the *North*-Point of the Hori-38 Degrees 30 Minutes, the Complement of the Latitude, n number 20½ Degrees the Sun's Declination on the Equi-tial-Colure, and bring that to the *East*-side of the Horizon, hall the Triangle be formed, and appear below the Hori-by A ⊙, an Arch of the Horizon. A B, an Arch of the inoctial. And B ⊙, an Arch of the Colure.

⊙ the Sun's Amplitude from the *East*, is numbred on Horizon to the Colure, and is 32 Degrees 26 Minutes.

B the Ascensional-Difference, is nambred on the Equinoc-from the *East*-Point of the Horizon to the Colure, and is eg. 15 Min. which reduced into Time, is 1 Hour 49 Min. re 6, for Sun-rise, *i. e.* 4 Hours 11 Minutes.

nd the Angle of the Sun's Position A ⊙ B, is found by inuing the Sides ⊙ A and ⊙ B to Quadrants, and then uring betwixt those two Points, as in the second and d *Problems*.

Prob. V.

the Right-angled Spherical-Triangle A E L, Right-angled Plate 3. Figure 4.

Given

Given { AL, the Sun's Declination equal to 20 Deg. 30 Min. N
LAE the Latitude equal to 51 Deg. 30 Min. *North.*

Required { LE, the Sun's Altitude at Six.
AE, the Sun's Azimuth from *East.*
ALE, the Sun's Position or Angle, which the Col
makes with the Vertical at Six.

To represent this Triangle *on the* Globe.

Elevate the Pole to the given Latitude, fix the Quadrant Altitude in the Zenith, and number the Sun's Declinati $20\frac{1}{2}$ Degrees on the Equinoctial-Colure, the Colure be brought to the *East*-Point of the Horizon, bring the grad ted Edge of the Quadrant, over the Sun's Declination on Colure, so will the Triangle be form'd by,

AL an Arch of the Colure equal to the Declination.
AE an Arch of the Horizon equal to the Azimuth, fr the *East.*
LE an Arch of the Quadrant equal to the Sun's Altitu

☞ AE, the Sun's Azimuth from *East* is 13 Deg. 6 M
LE, the Sun's Altitude at Six, is 15 Deg. 54 Min.
the Angle of the Sun's Position ALE, is found by conti ing the Sides LA and LE to Quadrants, and then measur betwixt those two Points, as in the second and third *Prob*

Of *Oblique-angled Spherical-Triangles.*

Prob. VI.

In the Oblique-angled Spherical-Triangle PZM, Pla Figure 5. Oblique-angled at Z.

Given { ZP, the Complement of the Latitude equal to 38 30 Min.
MP, the Sun's Distance from the Pole equal to 69 30 Min.
MZ, the Complement of the Sun's Altitude equa 47 Deg. 20 Min.

Required { PZM, the Sun's Azimuth from the *North,*
ZPM, the Hour of the Day from Noon.
ZMP, the Sun's Angle of Position.

To repreſent this Triangle *on the* Globe.

Elevate the Pole to the Latitude, then count Z P 38 Deg. 30 Min. the Complement of the Latitude from the Pole, on the *South*-Side of the Brazen Meridian, and where the Reckoning ends, ſcrew the Quadrant of Altitude, *i. e.* on the Zenith, which is markt 51 Deg. 30 Min. on the Braſs-Meridian this done, count the Side M P 69½ Deg. upon the Equinoctial-Colure from the Pole, and the Side M Z equal to 47 Deg. 20 Min. on the Quadrant of Altitude, from the Zenith downwards, and ſo move the Globe and Quadrant of Altitude together, till the Numbers counted on the Colure and Quadrant of Altitude, meet in one Point, ſo will the Triangle be exactly delineated upon the Globe.

Now to find the ſeveral Angles.

For the Angle Z, count the Number of Degrees of the Horizon, which are contained between the *North*-Point of the Meridian, and the Quadrant of Altitude 115 Deg. 35 Min. the Sun's Azimuth from the *North*.

For the Angle Z P M, the Degrees of the Equinoctial, contain'd between the *South*-Side of the Braſs Meridian, and the Colure 45 Deg. reduced into Time, is 3 Hours from Noon, *i. e.* 9 in the Morning, or 3 Afternoon.

For the Angle Z M P, the Angle of Poſition, reckon 90 Deg. from the Point M, on the Circles M Z and M P, the Diſtance betwixt thoſe Points meaſured by the Quadrant of Altitude, applied to both, give 36 Deg. 52 Min. the Angle ſought, made by the Meridian and Vertical concurring in M.

Alſo by having three Parts of any Oblique-Triangle given, the other three may be found, which afford no leſs Variety, than 60 Caſes in an Oblique, and 30 in a Right.

As will appear, if we call the Latitude 1. the Sun's Declination 2. Azimuth 3. Altitude 4. Poſition 5. Hour 6. Then may each of theſe be found from 10 different Data's

1	2	3	4	5	6
may be found from the Ten different *Data's*, directly underneath.					
1 2.3.4	1.5.6	1.5.6	1.5.6	2.3.4	2.3.4
2 2.3.5	1.4.6	1.4.6	2.3.5	1.4.6	2.3.5
3 2.3.6	1.4.5	1.4.5	2.3.6	2.3.6	1.4.5
4 2.4.5	1.3.6	2.4.5	1.3.6	1.3.6	2.4.5
5 2.4.6	1.3.5	2.4.6	1.3.5	2.4.6	1.3.5
6 2.5.6	1.3.4	2.5.6	2.5.6	1.3.4	1.3.4
7 3.4.5	3.4.5	1.2.6	1.2.6	1.2.6	3.4.5
8 3.4.6	3.4.6	1.2.5	1.2.5	3.4.6	1.2.5
9 3.5.6	3.5.6	1.2.4	3.5.6	1.2.4	1.2.4
10 4.5.6	4.5.6	4.5.6	1.2.3	1.2.3	1.2.3

Thus may we ſerve the five Parts of a Right-angled Spherical-Triangle.

Moreover, in the ſame Triangle, call the Side Z P the Diſtance of the Pole of the Equinoctial, from the Pole of the Ecliptic, then P M will be the Co-declination of a Star at M. Z M will be the Complement of the *North*-Latitude of that Star, the Angle M P Z, will be the Complement of the Stars Right-Aſcenſion; the Angle P Z M, the Stars-Longitude from ♋, and P M Z the Angle of the Stars Poſition.

The ſame Triangle may be applied to ſundry other Uſes in *Geography*, *Navigation*, and *Dialling*.

NAUTICAL PROBLEMS,

OR,

PROBLEMS

In *NAVIGATION*,

Solv'd by the

GLOBES.

SECT. VI.

PRÆCOGNITA.

THERE are four Fundamentals whereon the *Art of Navigation* depends. 1. The *Course* found by the Compass, regarding the Variation. 2. The *Distance* measured by e Log and Half-Minute-Glass, allowing for Lee-way. 3. e *Latitude* found by Celestial Observation of the Sun or Stars. The *Longitude* found by Help of two of the foregoing: o instrumental Way at Sea of immediately finding being t discovered, that hath been certain and practicable: That of dulum *Watches*, and the *Eclipses* of the *Satellites* of *Jupiter* bid e Fairest of any I know.

Before I begin any *Problem*, I shall premise a few Words of rse and *Distance*, as described on the *Globe*.

1. *Rhumb-Lines* make equal Angles with all Meridians on the obe.

2. An equal Part of the Rhumb altereth the Latitude equal- in all Places.

3. They are represented by Spiral-Lines winding about t Globe, and continue inclining towards the Pole, where th ſeem confuſed, never paſſing thro' the Poles.

4. The *Bearing* found by help of the Quadrant, is not t true Rhumb leading from one to the other, which may thus proved by finding the Bearing of the Second from Fir which will not be the oppoſite Point, but 'tis the Angle Poſition (*i. e.*) the Angle which the Arch of a great Circ paſſing vertically over the two Places makes with the Mer dian of the firſt Place.

5. A *Great Circle* inclining to the Meridian, maketh great Angles with all other Meridians, than with that from whe it was drawn.

6. By the *Diſtance* is to be underſtood the ſhorteſt Diſtan or their Diſtance in the Arch of a great Circle, which is l than their Diſtance in the Rhumb leading from one to t other, except both Places lye under one Meridian, or under Equator in as much as a great Circle on the Globe, like ſtrait Line on a Plane is the ſhorteſt of all Lines or Circles p ſible to be drawn.

7. Wherefore the *Diſtance* in the Rhumb muſt be thus l on or meaſured: Take a Degree or two of the Equator, turn it over upon the Rhumb, for if it be meaſured all at o Extent on the Rhumb then would it be the diſtance in Arch of a great Circle.

PROBLEM I.

To find the Difference of Latitude betwixt any t Places.

1. BRING both Places, either at once to the Meridian, in the ſame Longitude, or one after the other, if diff rent Longitudes. 2. The Degrees intercepted by th on the Meridian is the Difference of Latitude ſought.

PROB. II. *To find the Latitude, Hour, Sun's Al tude and Azimuth, the Globe, Sun-ſhine, a the Day of the Month.*

1. Fix the Globe Horizontally. 2. Set a Spheric Gnomo exactly on the Sun's Place (found againſt the Day of t Month on the Horizon) in the Ecliptic, which bring to t Meridian, and the Index to 12 at Noon. 3. Move the Glo upward and downward Eaſtward and Weſtward, till it caſt Shado

adow on any Side. 4. Then the Degree of the Me-ian cut by the Horizon is the Latitude ſought.

Note, The Index points at the Hour. Then apply e Quadrant to the Zenith, and over the Sun's Place on e Quadrant is the Altitude. And where the Quadrant en cuts the Horizon is the Azimuth on the Horizon.

herwiſe, By the Meridian-Altitude of Sun or Stars.

. Bring the Sun's Place or Star to the Meridian. 2. And n it count on the Meridian the Number of Degrees equal to e Meridian-Altitude given where the Count ends, bring to e *South*-Point of the Horizon, if obſerved on the *South*, but *rth*, if obſerved on the *North* off the Zenith. 3. So will Elevation of the Pole ſhew the Latitude.

SYNOPSIS of all the poſſible Varieties, that can happen in working an Obſervation at Sea.

or Stars tination.	Situation.	Sun's Shadow.	Rule.	What Latitude
N°	S°d.	N°d.	Add the Declination and Zenith Diſtance, the Sum is the Latitude.	N°
S°	N°d.	S°d.		S°
N°	N°d.	S°d.	The Difference of them is the Latitude, when the Zenith-diſtance is greater.	S°
S°	S°d.	N°d.		N°
N°	N°d.	S°d.	But when the Zenith-Diſtance is leſs than the Declination, the Difference is the Latitude.	N°
S°	S°d.	N°d.		S°
ne at all	N°d.	S°d.	The Zenith-Diſtance is the Latitude.	S°
	Zenith	No Shad.		O
	S°d.	N°d.		N°
N°	On the	No Sha-	The Declination is the	N°
S°	Zenith	dow.	Latitude.	S°

Note,

Note, { N° / S° / N°d. / S°d. } stands for { North / South / Northward / Southward } | 0 in the Latitu is nothing, co sequently und the Equator.

Betwixt the 10th of *March* and the 12th of *September* t Declination of the Sun is *North*, and betwixt the 12th of S tember and 10th of *March* the Declination is *South*.

But if the Sun or Star do not Riſe or Set in 24 Hou obſerve this General Rule.

If the Object obſerv'd be { under / above } the Pole the { Sum / Difference } of the Meri an-Altitude and Complement of Declination, is the Latitu of the ſame Name with the Declination.

Or without the Declination, obſerve the Meridian-Altitu when above the Pole, and when below: Half their Sum is t Latitude.

Prob. III. *To find the Difference of Longitu of two Places.*

1. Bring both Places to the Meridian, one after anoth diligently marking what Degree of the Equator is cut by t Meridian, when each Place is under the Meridian. 2. The D gree on the Equator ſo intercepted is the Difference of Lo gitude.

Note. The Degree of Longitude of one and the ſame Pla by different Authors, may vaſtly differ in Number, yet true; becauſe of the Variety of firſt Meridians, or Beginni of Longitude, which breed Confuſion; and the more, cauſe each Author doth not keep always the ſame, nor t whence he begins Longitude, and if ſome do, perhaps th tell not whether the *Eaſt*, *Weſt*, or Middle of the Iſland, t it were 3, 4, or 5 Degrees broad.

TABLE of the ſeveral firſt Meridians, by whom uſed, and their Difference in Longitude from *Pico de Teneriffa.*

			Deg.	Min.
o o ioſa ra ichaels a or *Fer.*	uſed by	the *Spaniſh*	15	55
		Mercator	13	25
		Moxon	10	25
		Dutch	9	
		Engliſh	8	5
		French	2	20

and differs from *Pico de Teneriffa*

e of which ſeem to me to have the chief Properties of a choſen firſt Meridian, which, with due Reſpect, I propoſe he Judgment of the Learned.

That it be on the Equator, becauſe thereon Longitude is oned.

That it be ſome ſmall Iſland not above half a Degree d to prevent Errors, whether Side of it ſoever Longitude nences.

That it ſtand by it ſelf, not confounded with other.

If it divided the two Continents, *America* from *Europe*, and *Africa*, it would be more conſpicuous.

on Search, in the *Dutch* Maps, ſuch a Place appears, called t, having all the above Properties *Weſt* from *Pico de Tene-* diſtant about 9 Degrees of Longitude, tho' to ſpeak ruth, I found it not elſewhere.

ntioning before in the Præcognita two inſtrumental of detecting Longitude, ſomething further concerning Manner follows.

B. IV. *To find the Longitude by* Pendulum-Watches.

Take at leaſt two Watches, that if one ſhould ſtop by iſhap or Neglect, the other may keep going.

Keep them cloſe, free from Moiſture or Duſt.

Let them be well adjuſted by an Equation-Table, before e taken to Sea, and kept going while at Sea.

Set them to the exact Moment of Time obſerved by the the Place left, regarding the Equation-Number.

hen arriving at the Place whoſe Longitude is ſought, exactly the Time by the Sun in that Place, and alſo by

by the Watch, allowing for the Equation; if they both ag exactly, there is no Difference of Longitude. But if the Ti of the Day there be greater than that ſhewn by the Watch then the Difference of Longitude is Eaſterly: but if Weſterly.

6. Convert the Difference of Time into Degrees, which be the Difference of Longitude in Degrees with greater Ex neſs than thoſe Ways that depend upon Tables, ſo vari among themſelves, ſuch as Calculations of Lunar-Eclipſes, which are as laborious as uncertain, and their true Beginni or Ending are ſcarce to be diſtinguiſhed for ſome Minu by Reaſon of the Penumbra: tho' four Minutes in Time alter the Longitude a whole Degree.

7. To convert Time into Degrees, or Degrees into Ti

	Time.				*Meaſure*	
	Hours.	*Min.*	*Sec.*		*Deg.*	*Mi*
Remember	1	0	0	} is equal to {	15	0
	0	4	0		1	0
	0	1	0		0	15
	0	0	4		0	1

	Hours.	*Min.*	*Sec.*		*Deg.*	*Mi*
Thus	3	42	32	=	55	3
For	3	0	0	=	45	0
	0	40	0	=	10	0
	0	2	0	=	0	3
	0	0	32	=	0	

8. Wherefore, conſidering the vaſt Improvement in W work by the Learned Dr. *Hook*, the Ingenious *Hugen.* whoſe very firſt Work, being try'd by Major *Holms.* pr both Satisfactory and Uſeful in a great Streight, and met Commendation, and the Approbation of the *States of H* inſomuch that he obtain'd a Patent for them; this ſeem its Readineſs, and to be done by one alone, no deſpi Way, tho' not infallible.

Prob. V. *To find the Longitude by the Satel of* Jupiter.

1. This above all claims the firſt Place by *Geographers*, cially by their Eclipſes, both becauſe they are frequent, being almoſt Momentaneous.

2. This (as before) requires the exact Time of their pening in both Places, either their Immerſion or Emer

which may be obtained by taking exactly the Altitude of a xed Star at the ſame Inſtant.

3. Reduce this Difference of Time into Degrees of Longiude, as before taught.

4. 'Tis true, as this is leſs fallible than the Former, ſo 'tis leſs racticable at Sea, as requiring a long Teleſcope not to be maaged well a Ship-board. alſo the joint Aſſiſtance of ſome able bſervators at both Places, tho' it may be of extraordinary ervice to rectify the Longitude of Sea-ports, when they are on and.

ROB. VI. *Betwixt two Places to find the* Courſe.

1. Obſerve the Rhumb that paſſeth thro' them, which is it: if none runs thro' them, that Rhumb which runs moſt paallel to them is the Courſe.

ROB. VII. *To find how many Miles are in a Degree of Longitude in any Latitude.*

1. In the given Parallel take 20 Degrees, and meaſure them n the Equator. 2. The Number whereof there tripled will ve the Number of Geographical Miles (60 of which make a egree of Latitude.)

ROB. VIII. *A Place given of a certain Diſtance from us, to find all the Places of like Diſtance.*

1. Rectify the Globe to our Latitude. 2. Bring that Place the Meridian. 3. To the Zenith affix the Quadrant. 4. ark what Degree of the Quadrant the other given Place ts. 5. All the Places paſſing under that Degree, while the lobe is turned round, are of the like Diſtance.

ROB. IX. Courſe *and* Diſtance *given; to find the Latitude and Longitude arrived at, ſuppoſing the Place left be known.*

1. Make a ſmall Mark on the Rhumb given in the Latitude the Place left. 2. Bring that Mark to the Meridian, which

then cuts the Equator in its Longitude, which we will c the Longitude left. 3. Reduce the Distance sail'd into Degre 4. Take one Degree from the Equator, and turn it over the Rhumb, as oft as there be Degrees in the Distance give 5. At the End of the Distance make a Mark, which bring the Meridian, whereon is the Latitude arrived at. 6. The M ridian cuts then also the Equator in the Longitude of t Point, which compared with the Longitude left, we get t Difference of Longitude, and consequently the Longitude rived at, if we add it to, or subtract it from the Longitu left, according as the Course hath been *East* or *West*.

PROB. X. *Both Latitudes and Course given; find their Distance, and Difference of Longitude.*

1. Turn the Globe till the given Rhumb cuts the Merid in the Latitude left. 2. There mark the Rhumb, and obse then the Degree of the Equator cut by the Meridian, call it the Longitude of Departure. 3. Turn the Globe till same Rhumb cut the Meridian in the Latitude arrived at, der which on the Rhumb make a Mark, and find the Lo tude of this second Mark, which compared with the Longit of Departure gives the Difference of Longitude. 4. T over a Degree of the Equator as oft as is possible betwixt two Marks on the Rhumb, for the Number of Degrees the Places are distant on the Rhumb.

PROB. XI. *The Latitude and Longitude of Places given; to find their Course and Distance.*

1. Find the Places themselves, then their Course and stance, by the Sixth *Problem* aforegoing.

Note. 'Tis best working these Questions on the Globe, w fewest Places are painted.

Note. By some of the foregoing *Problems*, the Mariner find the Way the Ship hath made, and make Pricks on Globe in their proper Places for every Day's Voyage, and sequently know where they are, how far from their fo ken Port or desired Haven, thus truly representing their age with less Trouble and more naturally than by any verse or Journal whatever.

PRO

ROB. XII. *The Diſtance of two Places ſituate on the ſame Meridian, with their Angles of Poſition they make with a third Place; to find that Place with its neareſt Diſtance from each of the other two.*

1. Rectify the Globe to the Latitude of the firſt, and fix the adrant to the Zenith. 2. To the Zenith bring the firſt given ace. 3. Extend the Quadrant to the Point of the Horizon which it bears off the Third. 4. By the Side of the Quaant make a ſmall Trace with Chalk. 5. Elevate the Pole to e Latitude of the ſecond Place. Bring it to the Meridian d the Quadrant to the Zenith. 6. Bring the Quadrant to at Point of the Compaſs on which it beareth from the Third. Where the Quadrant croſſeth the chalk'd Line is the third ace. whoſe Diſtance from the other two, find by the Degrees the Quadrant of Altitude.

Note, By this one may plot any new Land, obſerving its aring from two known Points. the Bearing and Angle of Poion not differing much in the narrow Compaſs of the ſenle Horizon.

ROB. XIII. *To take the Altitude of a Star.*

1. Fix the Globe Horizontal. 2. Move it up and down thro' the *South* Pole along the Axis the Star be directly . 3. Then the Degree of the Meridian intercepted by the rizon is the Stars Altitude.

ROB. XIV. *To learn the Names of the moſt noted Stars.*

Rectify the Globe to the Latitude. Day, and Hour of the Day; n if every Star on the Globe had a Hole, and the Eye was ced in the very Center of the Globe, and looking thro' h Hole, a direct Ray from the Eye thro' the Center of the t if extended to the Firmament, would cut the ſame Star the Heavens which that Star on the Globe repreſented: if Globe was duly rectified and ſet exactly level, and the Meridian *North*, then would the Stars that be,

Rising		Rising
On the Meridian		on the Meridian
On the Zenith	on the	on the Zenith
Setting	Globe be	Setting
On any Azimuth		on the ſame Azimuth
On any Almicanter		on the ſame Almican.

Wherefore, take the Azimuth or Amplitude by a Compa
or Altitude by a Quadrant of any Star whoſe Name is deſire
and find what Star hath the ſame Altitude and Azimuth by it
either its Name, or what Part of the Conſtellation it po
ſeſſes, as alſo its Magnitude, *&c.* It may be objected, th
the Planets ♃, ♂, and ♀ eſpecially, may cauſe the you
Beginner to miſtake, wherefore this ſhall be the next *Probl*

Prob. XV. *To diſtinguiſh the Planets from t fixed Stars.*

1. Planets don't twinkle commonly. 2. They are big
than ordinary, ♃ and ♀ eſpecially. 3. They are of di
ing Colors, ♄ of a leaden Color, and of third Magnitu
♃ bigger than the Firſt, of a Silver-Color, ♂ of the ſeco
Magnitude, of a Copper-Color, ♀ bigger than ♃, o
Gliſtering Color like new-coin'd Silver, ☿ of the th
Size, Pale, White, like Quick ſilver, never above 30 Degr
from the Sun, ſeldom ſeen but when he riſes before the S
or ſets juſt after the Sun. 4. they ſhift their Places i
Week or two obſervably from ſome known fixed S
5. Conſult an *Ephemeris* to ſee in what Sign the Planets
and if they are not in the Sign obſerv'd; know 'tis a fi
Star.

Prob. XVI. *To ſteer in the Night by the fi Stars.*

1. Rectify the Globe to the Latitude and Hour of the Day.
Then turn the Globe till the Difference of Longitude
paſſed thro' the Meridian, that is betwixt the Place left
the Place ſail'd to. 3. If any Star in the Latitude and Lo
tude aim'd at, come to or near the Meridian, that Sta
then in or near the Zenith of the Port deſired. Then

the Ship towards the ſame Star in the Heavens without
, ſtill obſerving what Star is in or near the Zenith of the
ce ſail'd to.

PROB. XVII. *By the Globe to find the Variation of the Compaſs.*

bſerve by the Compaſs on what Point the Sun riſes or
; by the Globe find the Sun's true Amplitude, if they
h agree, then is there no Variation, if not, their Difference
the Variation ſought. Which is Eaſterly, If the Sun
s on the Compaſs nearer the *North*, than on the Globe,
ſets on the Compaſs further from the *North* than on the
be. But Weſterly, if the Sun riſes on the Compaſs fur-
r from the *North* than on the Globe, or ſets on the Com-
s nearer to the *North* than on the Globe.
The like may be found at any Time by comparing the A-
uth by the Compaſs, and the Azimuth by the Globe in-
d of Amplitude.

PROB. XVIII. *Seeing two known Points or Capes of Land as we ſail along; to find the Ship's Diſtance from them, by knowing their Bearing.*

Pitch one Foot of a Pair of Compaſſes upon one Cape,
the other Foot upon the Rhumb which points towards
r Cape; do the like by the other Cape with another
r of Compaſſes, then move the Compaſſes ſo open'd by
ſe two Rhumbs off from the Land, the very ſame Point
ere the two Feet which came from the two Capes do
r, is the Point where the Ship is, whoſe Diſtance mea-
e by the Quadrant of Altitude.

ERRATA.

Page 20. *Line* 29 and 38 *for* Miles *read* Geographical Miles. *p.* 75. *l.* 33. *for* Depreſſion of a Star, *&c. read* Depreſſion of the Sun when a Star of the Magnitude riſes *Heliacally*.

PARA-

PARADOXES

To be Reſolved by the

GLOBES

WHEREAS *PATRICK GORDON* the ingenious Aut of the *Geographical Grammar* hath publiſh'd therein 45 verting and ſurprizing *Paradoxes*, of which, in my *Mathem cal-Miſcellany*, I have attempted a *probable* Solution, and th to have ſubjoined 55 more, with their *certain* Solution; which, when peruſed, will render the following *Paradoxes*, p poſed to the World by *G. GORDON* an eaſy and delig ful Entertainment, with which I conclude this Treatiſe *both Globes.*

I. *THERE is on the* Terraqueous Globe *a certain Pa of Latitude, to which a Ship may be ſuppoſed to ſail, an have Sea-room to depart from that Parallel; but ſuch is the Situa of every Point of that Parallel of Latitude, that no Ship can ſail f the ſaid Latitude, but upon one particular Point of the Compaſs; an Wind tho' it veer round all the 32 Points, will always blow ag that Point upon which the Ship muſt ſail from that Latitude, an Wind tho' blowing againſt the Point upon which the Ship muſt ſail, the Ship may go directly before the Wind.*

II. *There are two* Places *on the* Terraqueous Globe *ſo ſituated respect to one another, that from each of thoſe* Places *a Ship may and tho' they have Sea-room to all the 32 Points, yet it is impoſ for them to ſail from thoſe Places but upon oppoſite Points of the C paſs; and tho' they ſail upon oppoſite Points, yet they may, upon thoſe Po be either following or meeting one another.*

I. *There is a certain Place of the* Terraqueous Globe *to which the* Sun *and* Moon *riſe always in the* South, *and ſet in the* South.

II. *There are two Places of the* Earth *which bear directly* North *and* South *of one another, and their Diſtance from each other is* 100 *Miles, that the true* Courſe *from one of thoſe Places to the other is to ſail* 50 *Miles due* North, *and* 50 *Miles due* South.

III. *There is a certain Place on the* Terraqueous Globe *to which a Ship may ſail directly upon one Point of the* Compaſs; *but there are other fourteen Points on which a Ship may ſail towards that Place, but if ſhe continue to ſail upon e'er a one of the fourteen, ſhe will always approach nearer to the aforeſaid Place, but will never be able to come to it.*

IV. *There is a certain Parallel of Latitude upon which a Ship may ſail round the Globe, and may all that Time obſerve the Body of the* Sun, *without his being above the Horizon.*

V. *There is a certain Place of the* Earth *from which two Ships may depart on one and the ſame Day yea, and on the ſame Hour and Minute of that Day, and upon one and the ſame Point of the Compaſs, may continue to ſail with the ſame Velocity for the Space of* 24 *Hours, and tho' they depart from the ſame Place, and at the ſame Time, and both ſail upon the ſame Point of the* Compaſs, *with the ſame Velocity, yet in* 24 *Hours, they will be diſtant from one another above* 1000 Italian *Miles.*

VI. *There is a certain Parallel of Latitude upon which a Ship may ſail at the Rate of* 12 Italian *Miles an Hour and in* 24 *Hours her Velocity meaſured in Degrees of the Equator, ſhall be equal to the Velocity of the* Sun *on the* 10*th of* June.

VII. *There is a certain Place of the* Earth, *from which a Stone of about* 10000 *Weight could not fall, tho' a Pit were digged all round it, and that which is the Cauſe of other Bodies falling from other Places, would be the only Pillar to ſupport a Body in that Place.*

VIII. *There are two Parallels of Latitude, in one of which leſs Gold will make a Pound Weight than in the other.*

IX. *There are two Places of the* Earth *where one and ſame Veſſel will hold more Wine or Water in the one Place than in the other.*

X. *There is a certain Parallel of Latitude from which two Ships may ſail at one and the ſame Moment of Time, with reſpect of real Time and with reſpect of apparent Time, will differ one entire natural Day; but there is another Parallel of Latitude, to which, if thoſe two Ships ſail upon one and the ſame Point of the* Compaſs, *with the ſame Velocity, they ſhall arrive at that certain Parallel of Latitude at one and the ſame Moment, both with reſpect to real and apparent Time.*

XIII.

XIII. *There is a certain Place of the* Earth, *where all the fixed Stars* *ſtill the ſame Altitude; and notwithſtanding of the Diurnal Revol* *the* Earth, *they always bear upon the ſame Point of the* Compaſs.

XIV. *There are ſeveral Places at a conſiderable Diſtance from one another* *lie all directly* Eaſt *of* London, *but* London *does not lie directly* *from any of the ſaid Places.*

XV. *The* Chriſtians *obſerve the firſt Day of the Week for their* Sunday, Jews *the Seventh for their* Sabbath, *and the* Turks *the ſixth Day* *Week for the Time of their Worſhip; but there is a particular Place* *Globe to which, if a* Chriſtian, Jew, *and* Turk *ſail in one and the* *Ship, they ſhall keep the Time for their Worſhip on different Days, as* *all the Time they are ſailing to that particular Place; but when they* *at that Place, and during the Time they remain at it,* *ſhall all keep their* Sabbath *on one and the ſame Day; but when they* *part from that Place, they ſhall all differ as before.*

XVI. *There is a certain Port, from which, if three Ships depart at* *the ſame Time, and ſail on three particular different Courſes, till they* *to the Port they departed from, and if in one of theſe Ships be* Chriſ *in the ſecond* Jews, *and in the third* Turks, *when they return to* *they departed from, they ſhall differ ſo with reſpect to real and* *Time, that they all ſhall keep their* Sabbath *on one and the ſame* *the Week and yet each of them, ſeparately, ſhall believe that he* *Sabbath on the Day of the Week his Religion requires.*

XVII. *There is a certain Country in the* North-Temperate-Zone, *w* *Inhabitants the Bodies of the three Superior Planets,* Saturn, Jupiter, Mars *appear to be moſt enlighten'd, when they are actually leaſt enlig*

XVIII. *There is a Continent, all lying in the* North-Side *of the Equa* *whoſe Inhabitants the Body of the* Sun *ſeems to be neareſt to them, w* *is farthest removed from them.*

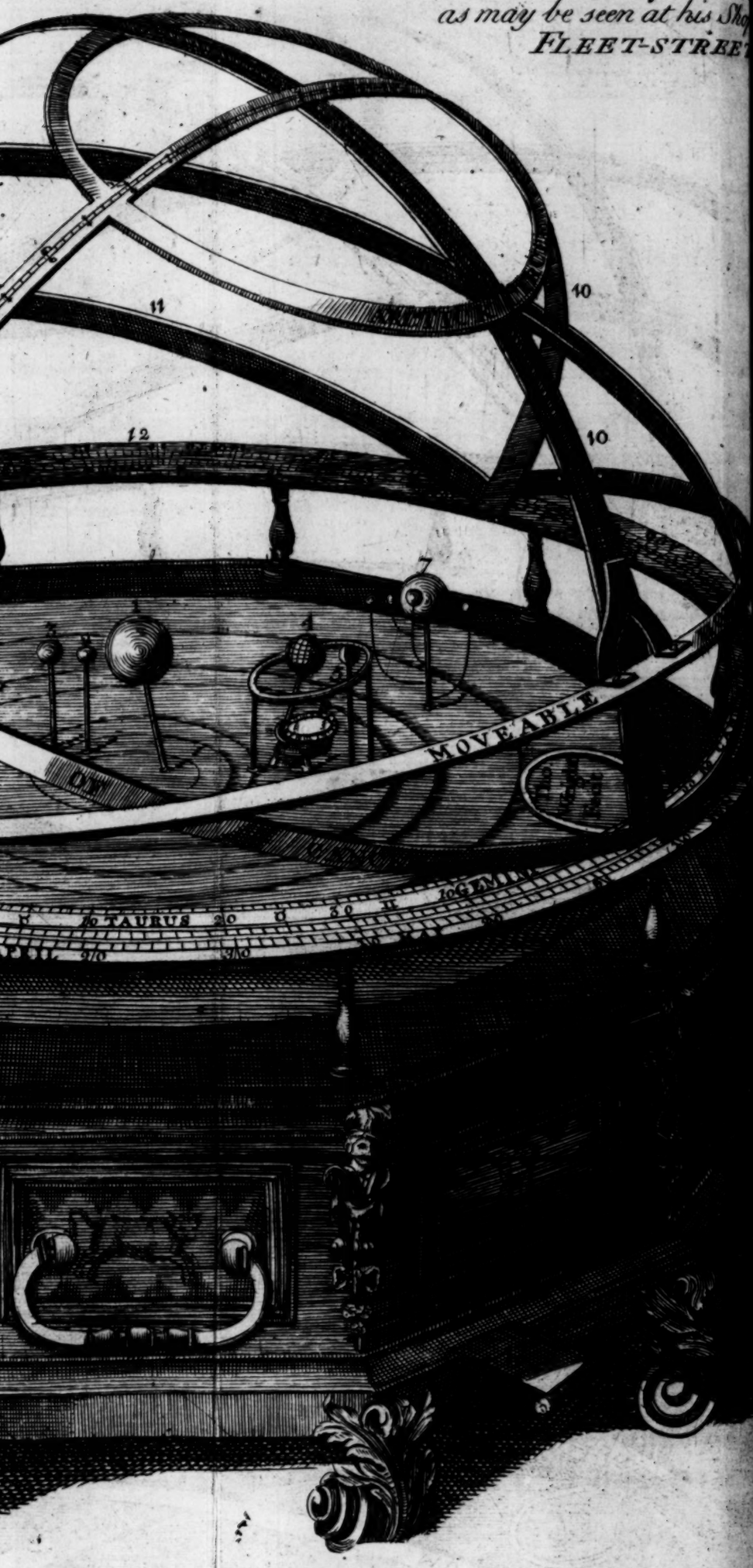
XIX. *There is a certain Parallel of Latitude, on which Parallel the Star,* *the* North-Polar-Star, *appears, by Obſervation, to be 47 Deg. el* *above the Horizon, and at another Time, the ſaid* Polar-Star *will* *by an Obſerver on the ſame Parallel of Latitude, to be at the Hori*

XX. *There are two Places lying in the* Torrid Zone *that are not abo* *Miles diſtant from one another, but if a Ship ſail from one to the oth* *one particular Point of the* Compaſs, *the Difference of Time betwee* *two Places will actually be found to be above 23 Hours.*

XXI. *There are 24 Places on the* Terraqueous Globe, *in which all* *Hours of the natural Day do always exiſt at the ſame Time and* *the Diſtance of any two of thoſe Places does not exceed 60 Miles.*

The GREAT ORRERY
Four Feet in Diameter. *Made by*
Tho: WRIGHT Mathematical Instru-
ment maker TO HIS MAJESTY

Who makes Orrery's of differ
as may be seen at his Sho
FLEET-STREE



J G

THE

DESCRIPTION

OF THE

ORRERY,

tely made by THO. WRIGHT, Ma-hematical Inſtrument-Maker *to His* MAJESTY.

THE ORRERY is an Aſtronomical Machine, made to repreſent the Motions of the Planets, as they really are in Nature: Theſe Machines are made of various Sizes, ſome having more Planets than ; but I ſhall here confine my ſelf to the Deſcription of bove mentioned. *Orrery.*

Frame which contains the Wheel-Work, *&c.* egulates the whole *Machine*, is made of fine Ebo- nd is near four Feet in Diameter; the outſide f is adorned with twelve Pilaſters, curiouſly ht and gilt: Between theſe Pilaſters, the twelve Signs of odiac are neatly painted, within gilded Frames. Above ame is a broad Ring, ſupported with twelve : This Ring repreſents the *Plane* of the *Ecliptic*, which there are two Scales of Degrees, and be- thoſe the Names and Characters of the twelve Near the Outſide is a Scale of Months and Days. exactly *The Deſcription of the Orrery.*

Vide Orrery p. 121.

 correſponding

correſponding to the Sun's Place at Noon, each Day throughout the Year.

Above the Ecliptic ſtand ſome of the principal Circles of the Sphere, according to their reſpective Situation in the Heavens, *viz.* N° 10, are the two *Colures*, divided into Degrees and Half Degrees: N° 11, is one Half of the Equinoctial Circle making an Angle with the Ecliptic of 23½ Degrees: The *Tropic* of *Cancer* and the *Arctic Circle* are each fixed parallel, and at their proper Diſtance from the Equinoctial. On the Northern Half of the Ecliptic, is a braſs Semicircle, moveable upon two Points fixed in ♈ and ♎: This Semicircle ſerves as a moveable Horizon, to be put to any Degree of Latitude upon the *North* Part of the Meridian. The whole Machine is alſo contrived, as to be ſet to any Latitude, without affecting in the leaſt any of the inſide Motions: For this purpoſe there are two ſtrong Hinges (N° 13.) fixed to the bottom Frame, upon which the Inſtrument moves, and a ſtrong Braſs Arch, having Holes at every Degree, thro' which a ſtrong Pin is to be put according to the Elevation. This Arch, and the two Hinges ſupport the whole Machine, when it is lifted up according to any Latitude; and the Arch at other times lies conveniently under the bottom Frame.

When the Machine is ſet to any Latitude (which is eaſily done, by two Men, each taking hold of two Handles, conveniently fixed for that purpoſe) ſet the moveable Horizon to the ſame Degree upon the Meridian, and you may form an Idea of the reſpective Altitudes or Depreſſions of the Planets, above or below the Horizon, according to their reſpective Poſition with regard to the Meridian.

Within the Ecliptic, and nearly in the ſame Plane there ſtand the Sun, and all the Planets both Primary and Secondary. The *Sun* (N° 1.) ſtands in the middle of the whole Syſtem, on a Wire making an Angle with the Plane of the Ecliptic of about 82 Degrees, which is the Inclination of the Sun's Axis, to the Axis of the Ecliptic. Next the Sun is a ſmall Ball, (N° 2.) repreſenting *Mercury*: Next to *Mercury* is *Venus* (N° 3.) repreſented by a larger Ball, (and both theſe ſtand upon Wires, ſo that the Balls themſelves may be more viſibly perceived by the Eye.) The Earth is repreſented (N° 4) by an Ivory Ball having ſome of the principal Meridians and Parallels and a little Sketch of a Map deſcribed upon it. The Wire which ſupports the Earth makes an Angle with the Plane of the Ecliptic of 66½ Degrees, which is the Inclination of the Earth's Axis to that of the Ecliptic. Near the Bottom of the Earth's Axis is a Dial-Plate, (N° 9.) having an Index pointing to the Hours of the Day, as the Earth turns round its Axis.

Ro

Round the Earth is a Ring ſupported by two ſmall Pillars; hich Ring repreſents the Orbit of the Moon, and the Diviſi-ns upon it anſwer to the Moon's Latitude; the Motion of is Ring repreſents the Motion of the Moon's Orbit according that of the Nodes. Within this Ring is the Moon (N° 5.) ving a black Cap or Caſe, which by its Motion repreſents e *Phaſes* of the Moon according to her Age. Without the Or-ts of the Earth and Moon is *Mars* (N° 6.) The next in Order *Mars*, is *Jupiter* and his four Moons, (N° 7.); each of theſe oons is ſupported by a crooked Wire, fixed in a Socket which rns about the Pillar that ſupports *Jupiter*: theſe Satellits may turned by the Hand to any Poſition; and yet when the Ma-ine is put in motion, they'll all move in their proper Times. he outermoſt of all is *Saturn* and his five Moons, (N° 8.) theſe oons are ſupported and contrived after the ſame manner with oſe of *Jupiter*. The whole Machine is put into Motion by rning a ſmall Winch, (like the Key of a Clock, N° 14); and the inſide Work is ſo truly wrought, that notwithſtanding e vaſt Number of Wheels that are to be turned, it does not quire above the Strength of a fine Hair to put the whole in otion.

Above the Handle, there is a Cylindrical Pin, which may be wn a little out, or puſhed in at pleaſure: When it is puſhed all the Planets both Primary and Secondary will move ac-rding to their reſpective Periods, by turning the Handle: en it is drawn out, the Motions of the Satellits of *Jupiter* d *Saturn* will be ſtopped, while all the reſt move without in-ruption. This is a very good Contrivance to preſerve the ſtrument from being clogged by the ſwift Motions of the heels belonging to the Satellits of *Jupiter* and *Saturn*, when e Motions of the reſt of the Planets are only conſidered.

There is alſo a braſs Lamp, having two convex Glaſſes, to be t in the room of the Sun; and alſo a ſmaller Earth and Moon, de ſomewhat in Proportion to their Diſtance from each other, ich may be put on at pleaſure.

The Lamp turns round in the ſame time with the Earth, d by means of the Glaſſes caſts a ſtrong Light upon her: and en the ſmaller Earth and Moon are placed on, it will be y to ſhew when either of them may be eclipſed.

Having thus given a brief Deſcription of the outward Parts this Machine. I ſhall next give an Account of the Phæno-na explained by it, when it is put into Motion.

I. *Of the Motions of the Planets in general.*

Having put on the Handle, puſh in the Pin which is ju above it, and place a ſmall black Patch (or bit of Wafer) u on the middle of the Sun (for Inſtance) right againſt the fir Degree of ♈; we may alſo place Patches upon *Venus*, *Mars* an *Jupiter*, right againſt ſome noted Point in the Ecliptic. I we lay a Thread from the Sun to the firſt Degree of ♈, w may ſet a Mark where it interſects the Orbit of each Planet; an that will be a help to note the Time of their Revolutions.

One entire Turn of the Handle anſwers to the Diurnal Mo tion of the Earth round her Axis; as may be ſeen by the Mo tion of the Hour-Index which is placed at the Foot of the Wi on which the Terella is fixed. When the Index has moved t ſpace of ten Hours, we may obſerve that *Jupiter* has made o Revolution complete round its Axis; the Handle being turne until the Hour-Index has paſſed over 23 Hours, will bring t Patch upon *Venus* to its former Situation with reſpect to t Ecliptic, which ſhews that ♀ has made one entire Revolutio round her Axis. *Mars* makes one complete Revolution roun his Axis in 24 Hours and about 40 Minutes. When the Hand is turned 27 times round, the Spot upon the Sun will point t the ſame Degree of the Ecliptic, as it did when the Inſtrumen was firſt put into Motion. By obſerving the Motions of th Spots upon the Surface of the Sun, and of the Planets in th Heavens, their Diurnal Motion was diſcovered; after the ſam manner as we do here obſerve the Motions of their Repreſen tatives, by that of the Marks placed upon them.

If while we turn the Handle we obſerve the Planets, w will ſee them perform their Motions in the ſame relative Tim as they really do in the Heavens; each making its Period i the Times mentioned in the Tables of their Periodic Revo lutions 27⅓ Turns of the Handle will bring the Moon roun the Earth, which is called a *Periodic* Month, and all the whi ſhe keeps the ſame Face towards the Earth: for the Moon's An nual and Diurnal Motion are performed both in the ſame Tim nearly, ſo that we always ſee the ſame Face or Side of th Moon.

If before the Inſtrument is put into Motion, the Satelli of *Jupiter* and *Saturn* be brought into the ſame right Line fro their reſpective Primaries, we'll ſee them as we turn the Han dle immediately diſpers'd from one another, according to the different Celerities. Thus, one turn of the Handle will brin the firſt of *Jupiter*'s Moon's about ⅘ parts round *Jupiter*; whil th

he ſecond has deſcribed but ⅔ parts; the third but about ½; nd the fourth not quite $\frac{1}{10}$ part; each of its reſpective Orbit. f we turn the Handle until the Hour-Index has moved 18½ ours more; the firſt Satellit will be then brought into its for- er Poſition, and ſo has made one entire Revolution; the econd at the ſame time will be almoſt diametrically oppoſite o the firſt; and ſo has made a little more than Half of one evolution: the others will be in different Aſpects, according o the Length of their Periods, as will be plainly exhibited by he Inſtrument. The ſame Obſervations may be made with re- pect to the Satellits of *Saturn*.

The Machine is ſo contrived, that the Handle may be turn- d either way; and if before we put it into motion, we ob- erve the Aſpects (or Situation with reſpect to each other) of e Planets, and then turn the Handle round any Number of imes; the ſame number of Revolutions being made backwards, ill bring all the Planets to their former Situations. I ſhall ext proceed to Particulars.

Of the Stations and Retrogradations of the Planets.

The Primary Planets, as they all turn round the Sun, at dif- rent Diſtances and in different Times, appear to us from the arth to have different Motions; as ſometimes they appear to ove from *Weſt* to *Eaſt* according to the Order of the Signs, hich is called their *direct* Motion; then by degrees they ſlacken eir pace, until at laſt they loſe all their Motion nd become *Stationary*, or not to move at all; that , they appear in the ſame place with reſpect to the xed Stars for ſome time together: After which they again be- n to move, but with a contrary Direction, as from ſt to *Weſt*; which is called their *retrograde* Motion: en again they become Stationary, and afterwards aſſume their direct Motion. The Reaſon of all eſe Appearances is very evidently ſhewn by the *Orrery*.

Stationary.

Retrograde Motion of the Planets.

I. *Of the Stations, &c. of the inferior Planets.*

We ſhall inſtance in the Planet *Mercury*, becauſe his Motion ound the Sun differs more from the Earth's than that of *Venus* oes.

When *Mercury* is in his ſuperior Conjunction (or when he is a direct Line from the Earth beyond the Sun) faſten a String bout the Axis of the Earth, and extend it over *Mercury* to the Ecliptic;

Ecliptic; then turning the Handle, keep the Thread all the while extended over ☿, and we'll find it move with a direct Motion in the Ecliptic, but continually slower, until *Mercury* has the greatest Elongation from the Earth. Near this Position, the Thread for some time will lay over *Mercury* without being moved in the Ecliptic, tho' the Earth and *Mercury* both continue their progressive Motion in their respective Orbits. When *Mercury* has got a little past this Place, we'll find the Thread must be moved backward in the Ecliptic, beginning first with a slow Motion, and then faster by degrees, until *Mercury* is in his inferior Conjunction, or directly betwixt the Earth and the Sun. Near this Position of ☿, his retrograde Motion will be the swiftest; but he still moves the same way, tho' continually slower, till he has again come to his greatest Elongation, where he will appear the second time to be Stationary; after which, he begins to move forward, and that faster by degrees, until he is come to the same Position, with respect to the Earth, that he was in at first. The same Observations may be made relating to the Motions of *Venus*. In like manner the different Motions observed in the superior Planets, may be also explained by the *Orrery*. If we extend the Thread over *Jupiter* and proceed after the same manner as before we did in regard to *Mercury*; we'll find that from the time *Jupiter* is in Conjunction with the Sun, his Motion is direct, but continually slower until the Earth is nearly in a Quadrat Aspect with *Jupiter*, near which Position *Jupiter* seems to be Stationary: after which he begins to move, and so continually mends his Pace until he comes in Opposition to the Sun, at which time his retrograde Motion is swiftest. He still seems to go backward, but with a slower Pace, till the Earth and he are again in a Quadrat Aspect, where *Jupiter* seems to have lost all his Motion; after which he again resumes his direct Motion and so proceeds faster by degrees, till the Earth and he are again in Opposition to each other.

Plate 5. *Fig* 1. These different Motions observed in the Planets are easily illustrated, as followeth: The lesser Circle round the Sun is the Orbit of *Mercury*, in which he performs his Revolution round the Sun in about three Months, or while the Earth is going through ¼ part of her Orbit or from A to N. The Numbers 1, 2, 3 *&c.* in the Orbit of *Mercury* shew the Spaces he describes in a Week nearly; and the Distances AB, BC, CD, *&c.* in the Earth's Orbit do likewise shew her Motion in the same Time. The Letters A, B, C, *&c.* in the great Orb, are the Motions of *Mercury* in the Heavens, as they appear from the Earth. Now if the Earth be supposed in A, and *Mercury* in 12, near his superior Conjunction with

he Sun, a Spectator on the Earth will ſee ☿, as if he were in he Point of the Heavens A; and while ☿ is moving from 12 o 1, and from 1 to 2, *&c.* the Earth in the ſame time alſo moves rom A to B, and from B to C, *&c.* All which time ☿ appears n the Heavens to move in a direct Motion from A to B, and rom B to C, *&c.* but gradually ſlower until he arrives near he Point G, near which place he appears Stationary, or to and ſtill: and afterwards (tho' he ſtill continues to move uniformly in his own Orbit with a progreſſive Motion) yet in the phere of the fixed Stars he'll appear to be retrograde, or to go ackwards, as from G to H, from H to I, *&c.* until he has arrived near the Point L, where again he'll appear to be Stationary, and afterwards to move in a direct Motion from L to M, nd from M to N, *&c.*

What has been here ſhewn concerning the Motions of *Mercury*, is alſo to be underſtood of the Motions of *Venus*; but the Conjunctions of *Venus* with the Sun, do not happen ſo often s in *Mercury*: for *Venus* moving in a larger Orbit, and much lower than *Mercury*, does not ſo often overtake the Earth. But he Retrogradations are much greater in *Venus* than they are in *Mercury*, for the ſame Reaſons.

The innermoſt Circle repreſents the Earth's Orbit, *Fig.* 2. ivided into 12 Parts, anſwering to her Monthly Motion: the greateſt Circle is the Orbit of *Jupiter*, which he deſcribes in about 12 Years; and therefore the $\frac{1}{12}$ thereof, from A to N, defines his Motion in one of our Years nearly; and he intermediate Diviſions, A, B, C, *&c.* his monthly Motion. Let us ſuppoſe the Earth to be in the Point of her Orbit 12, nd *Jupiter* in A, in his Conjunction with the Sun: It is evident that from the Earth, *Jupiter* will be ſeen in the Great Orb, r in the Point of the Heavens A; and while the Earth is moving from 12 to 1, 2, *&c.* ♃ alſo moves from A to B C *&c.* ll which Time he appears in the Heavens to move with a direct Motion from A to B, C, *&c.* until he comes in Oppoſition to the Earth near the Point of the Heavens E, where he appears to be Stationary: After which, ♃ agains begins to move (tho' at firſt with a ſlow Pace) from E thro' F, H, I, to K; where again he appears to ſtand ſtill; but afterwards he reaſſumes his direct Motion from I thro' K, to M, *&c.*

From the Conſtruction of the preceding Figure, it appears that when the Superior Planets are in Conjunction with the Sun, their direct Motion is much quicker than at other times; and that becauſe they really move from *Weſt* to *Eaſt*, while the Earth in the oppoſite Part of the Heavens is carried the ſame Way, and round the ſame Center. This Motion afterwards continually ſlackens until the Planet comes almoſt in Oppoſition

tion to the Sun, when the Line joining the Earth and Pl
will continue for ſome time nearly parallel to it ſelf, and
the Planet ſeems from the Earth to ſtand ſtill; after wh
it begins to move with a ſlow Motion backward, until it co
into a Quartil Aſpect with the Sun, when again it will ap
to be Stationary for the above Reaſons. After that, it
reſume its direct Motion until it comes into a Conjun
with the Sun, then it will proceed as above explained. He
it alſo appears that the Retrogradations of the ſuperior Pla
are much ſlower than their direct Motions, and their conti
ance much ſhorter; for the Planet, from its laſt Quarter,
til it comes in Oppoſition to the Sun, appears to move the ſa
way with the Earth, by whom it is then overtaken; A
which it begins to go backwards, but with a ſlow Motion,
cauſe the Earth being in the ſame part of the Heavens,
moving the ſame way, that the Planet really does, the appa
Motion of the Planet backwards muſt thereby be leſſened.

What has been here ſaid concerning the Motions of *Ju*
is alſo to be underſtood of *Mars* and *Saturn*. But the Retro
dations of *Saturn* do oftner happen than thoſe of *Jupiter*,
cauſe the Earth oftner overtakes *Saturn*; and for the ſame
ſon, the Regreſſions of *Jupiter* do oftner happen than thoſ
Mars. But the Retrogradations of *Mars* are much greater
thoſe of *Jupiter*; whoſe are alſo much greater than thoſe
Saturn.

In either of the Satellits of *Jupiter* or *Saturn*, theſe diffe
Appearances in the neighbouring Worlds, are much oftner
than we do in the Primary Planets.

We never obſerve theſe different Motions in the Moon
cauſe ſhe turns round the Earth as her Center; neither do
obſerve them in the Sun, becauſe he is the Center of the Ear
Motion, whence the apparent Motion of the Sun always
pears the ſame way round the Earth.

Of the Annual and Diurnal Motion of the Earth, and of the Increaſe and Decreaſe of Days and Nights.

The Earth in her Annual Motion round the Sun, has
Axis always in the ſame Direction, or parallel to it ſelf:
is, if a Line be drawn parallel to the Axis while the Earth
in any point of her Orbit, the Axis in all other Poſitions
the Earth, will be parallel to the ſaid Line. This Parallel
of the Axis, and the ſimple Motion of the Earth in the Ec
tic, ſolves all the Phænomena of different Seaſons. Theſe thi
are very well illuſtrated by the *Orrery*.

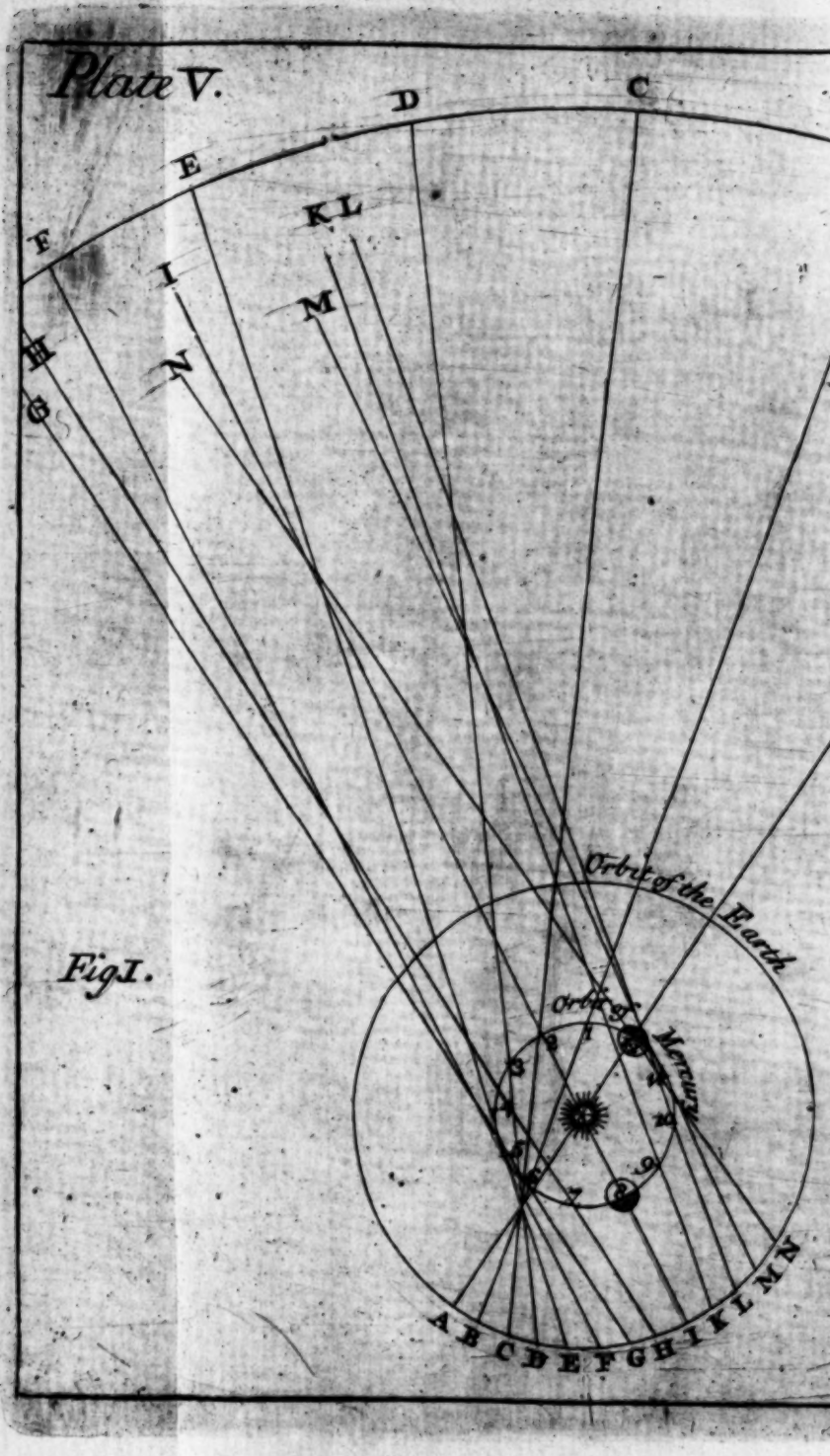
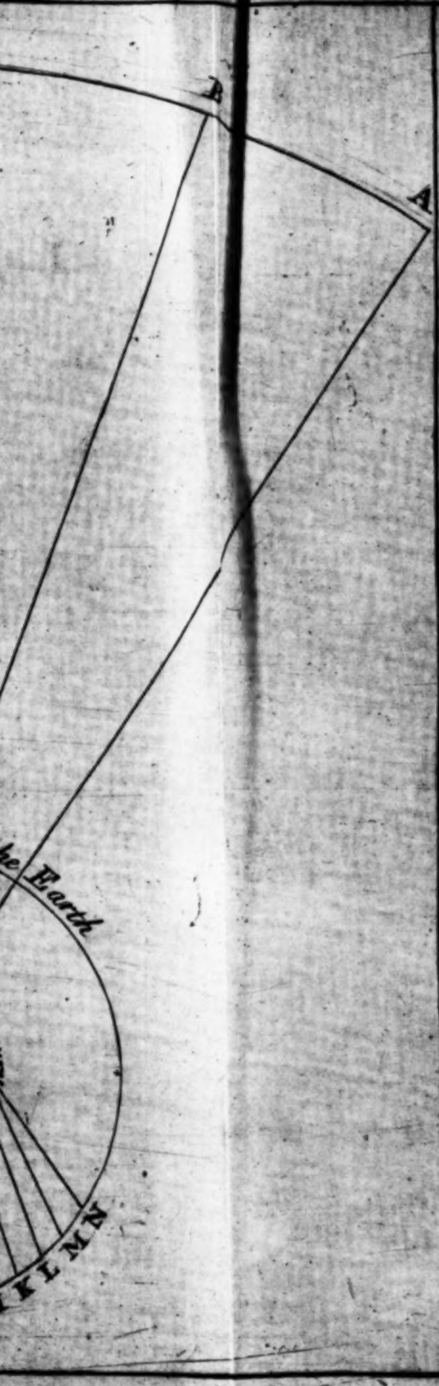


Plate V.
D
C
E
F
KL
I
M
H
N
G
Orbit of the Earth
Orbit of Mercury
A B C D E F G H I K L M N
Fig I.

fronting Page 128



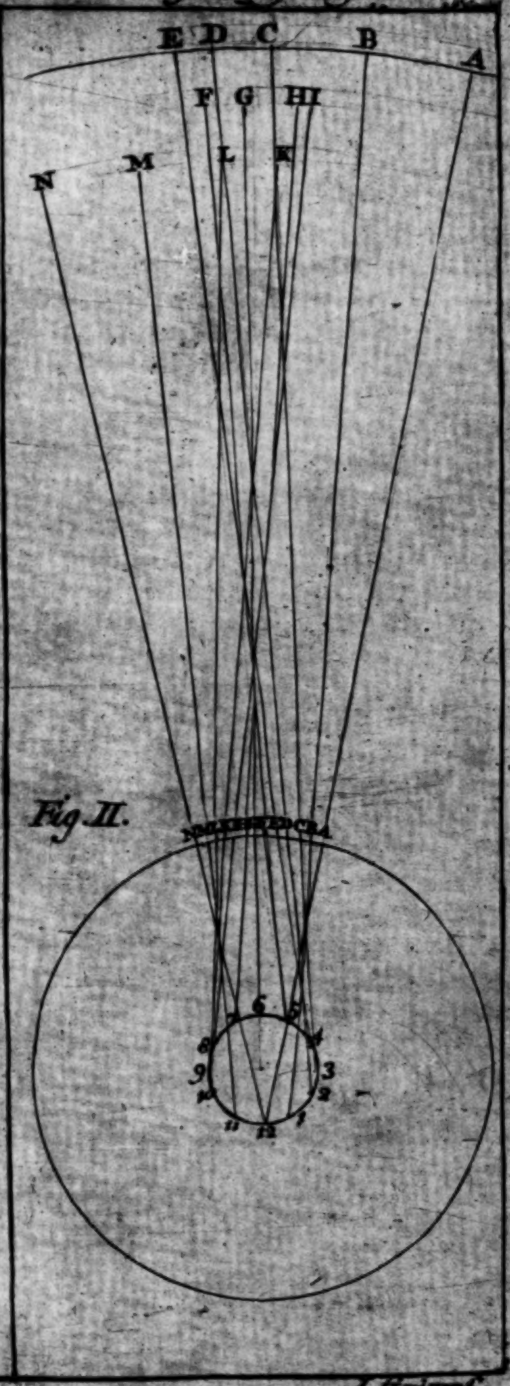


Fig. II.

J Grimes sc.

ve put on the Lamp in the place of the Sun, we will ſee
one half of our Globe is always illuminated by the Sun,
the other Hemiſphere remains in Darkneſs; how Day and
are formed by the Revolution of the Earth round her
for as ſhe turns from *Weſt* to *Eaſt*, the Sun appears to
from *Eaſt* to *Weſt*. And while the Earth turns in her
we may obſerve that her Axis always points the ſame
and the ſeveral Seaſons of the Year continually change.
make theſe things plainer, we will take a View of the
in different parts of her Orbit.

en the Earth is in the firſt Point of *Libra* (which is found
ending a Thread from the Sun, and over the Earth to the
ic) we have the *Vernal Equinox*, and the Sun at that Time
s in the firſt Point of ♈. In this Poſition of the Earth,
vo Poles of the World are in the Line ſeparating Light
arkneſs; and as the Earth turns round her Axis, juſt one
f the Equator, and all its Parallels, will be in the Light,
e other Half in the Dark; and therefore the Days and
s muſt be every where equal.

he Earth moves along in her Orbit, we'll perceive the
Pole advances by degrees into the illuminated Hemiſ-
and at the ſame Time, the *South* Pole recedes into Dark-
and in all Places to the Northward of the Equator, the
ontinually lengthen, while the contrary happens in the
rn Parts; until at length the Earth is arrived in *Capri-*
In this Poſition of the Earth, all the Space included with-
Arctic Circle falls wholly within the Light; and all
poſite Part lying within the Antarctic Circle, is quite
ed in Darkneſs. In all Places between the Equator and
rctic Circle, the Days are now at the longeſt, and are
lly longer as the Places are more remote from the Equa-
n the Southern Hemiſphere there is the contrary Effect.
e while the Earth is travelling from *Capricorn* towards
he *North* Pole gradually recedes from the Light, and the
ole approaches nearer to it: the Days in the Northern
phere gradually decreaſe, and in the Southern Hemiſphere
ncreaſe in the ſame proportion, until the Earth being ar-
n ♈, then the two Poles of the World lie exactly in the
eparating Light and Darkneſs, and the Days are equal to
ights in all Places of the World. As the Earth advances
ds *Cancer*, the *North* Pole gradually recedes from the Light,
the Southern one advances into it, at the ſame rate; in
rthern Hemiſphere the Days decreaſe, and in the Southern
hey gradually lengthen, until the Earth being arrived in
the *North* Frigid Zone is all involved in Darkneſs, and
th Frigid Zone falls entirely within the Light; the Days

every where in the Northern Hemisphere are now at the shortest, and to the Southward they are at the longest. As the Earth moves from hence towards *Libra*, the *North* Pole gradually approaches the Light, and the other recedes from it; and in Places to the Northward of the Equator, the Days now lengthen, while in the opposite Hemisphere they gradually shorten, until the Earth has got into ♎; in which Position, the Days and Nights will again be of equal Length in all Parts of the World.

We might have observed, that in all Positions of the Earth one half of the Equator was in the Light, and the other half in Darkness; whence under the Equator, the Days and Nights are always of the same Length: And all the while the Earth was going from ♎ towards ♈, the *North* Pole was constantly illuminated, and the *South* Pole all the while in Darkness; and for the other Half Year the contrary. Sometimes there is a Semicircle exactly facing the Sun, fixed over the Middle of the Earth, which may be called the Horizon of the Disk: This will do instead of the Lamp, if that Half of the Earth which is next the Sun be consider'd as being the illuminated Hemisphere, and the other Half, to be that which lies in Darkness.

Plate 6. The Great Circle ♈, ♉, ♊, *&c.* represents the Earth's annual Orbit; and the four lesser Circles E S Q C, the Ecliptic upon the Surface of the Earth, coinciding with the great Ecliptic in the Heavens. These four lesser Figures represent the Earth in the four Cardinal Points of the Ecliptic; P being the *North* Pole of the Equator, and *P* the *North* Pole of the Ecliptic; S P C the Solstitial Colure, which is always parallel to the great Solstitial Colure ♋ ☉ ♑ in the Heavens; E P Q the Equinoctial Colure. The other Circles passing thro' P, are Meridians at two Hours distance from one another; the Semicircle E Æ Q is in the Northern Half of the Equator; the parallel Circle touching the Ecliptic in S, is the Tropic of *Cancer*; the dotted Circle the Parallel of *London*; and the small Cicle, touching the Pole of the Ecliptic, is the *Arctic Circle*. The shaded Part, which is always opposite to the Sun, is the obscure Hemisphere, or that which lies in Darkness; and that which is next the Sun, is the illuminated Hemisphere.

If we suppose the Earth in ♎, she'll then see the Sun in ♈ (which makes our Vernal Equinox) and in this Position, the Circle, bounding Light and Darkness, which here is S C, passes thro' the Poles of the World, and bisects all the Parallels of the Equator; and therefore the Diurnal and Nocturnal Arcs, or the Lengths of the Days and Nights are equal in all Places of the World.

ut while the Earth, in her annual Courſe, moves thro' ♐ to ♑; the Line S C, keeping ſtill parallel to it ſelf, or the Place where it was at firſt; the Pole P, will by this Mon gradually advance into the illuminated Hemiſphere; and the Diurnal Arches of the Parallels gradually increaſe, and conſequently the Nocturnal ones decreaſe in the ſame proportion, until the Earth has arrived into ♑: in which Poſition Pole P, and all the Space within the Arctic Circle, fall olly within the illuminated Hemiſphere; and the Diurnal ches of all the Parallels that are without this Cicle, will exd the Nocturnal Arches more or leſs, as the Places are near- to, or farther off from it; until the Diſtance from the Pole as far as the Equator, where both theſe Arches are always al.

gain, while the Earth is moving from ♑ through ♒, ♓, ♈; the Pole P begins to incline to the Line, diſtinguiſhing ht and Darkneſs, in the ſame proportion that before it reed from it; and conſequently the Diurnal Arches gradually en, until the Earth has arrived into ♈; where the Pole P l again fall in the Horizon, and ſo cauſe the Days and hts to be every where equal. But when the Earth has paſ- ♈, while ſhe is going thro, ♉ and ♊ *&c.* the Pole P l begin to fall in the obſcure Hemiſphere, and ſo recede grally from the Light, until the Earth is arrived in ♋; in ch Poſition, not only the Pole, but all the Space within Arctic Circle, are involved in Darkneſs; and the Diurnal hes of all the Parallels, without the Arctic Circle, are equal he Nocturnal Arches of the ſame Parallels, when the Earth in the oppoſite Point ♑; and it is evident, that the Days now at the ſhorteſt, and the Nights the longeſt. But when Earth has paſt this Point, while ſhe is going through ♌, ♍, the Pole P will again gradually approach the Light, and ſo diurnal Arches of the Parallels gradually lengthen, until the h is arrived in ♎; at which Time the Days and Nights will n be equal in all Places of the World, and the Pole it ſelf ſee the Sun.

ere we only conſidered the Phænomena belonging to the rthern Parallels; but if the Pole P be made the *South* Pole, n all the Parallels of Latitude will be Parallels of *South* Lati- e; and the Days every where, in any Poſition of the Earth, l be equal to the Nights of thoſe who lived in rhe oppoſite miſphere, under the ſame Parallels.

Of the Phaſes of the Moon, and of her Motion in h Orbit.

The Orbit of the Moon makes an Angle with the Plane the Ecliptic, of above 5½ Degrees, and cuts it into two Poin diametrically oppoſite, (after the ſame manner as the Equa and the Ecliptic cut each other upon the Globe

Nodes. ♈ and ♎) which Points are called the *Nodes*; a a right Line joining theſe Points, and paſſing throu

Line of the Nodes. the Center of the Earth, is called the *Line of the N* That Node where the Moon begins to aſcend Nor ward above the Plane of the Ecliptic, is called t

Dragon's Head. *Aſcending Node*, and the *Head of the Dragon*, and thus commonly marked ☊. The other *Node*, fr whence the Moon deſcends to the Southward of the Eclipt is called the *Deſcending Node*, and the *Dragon's T*

Dragon's-Tail. and is marked ☋. The Line of the Nodes contin ally ſhifts it ſelf from *Eaſt* to *Weſt*, contrary to t

Retrograde Motion of the Nodes. Order of the Signs; and with this *Retrograde* Motio makes one Revolution round the Earth, in the Spa of about 19 Years.

The Moon deſcribes its Orbit round the Earth in the Spa of 27 Days, and 7 Hours, which Space of Time

Periodical Month. called a *Periodical Month*; yet from one Conjunctio to the next, the Moon ſpends 29 Days and a Ha

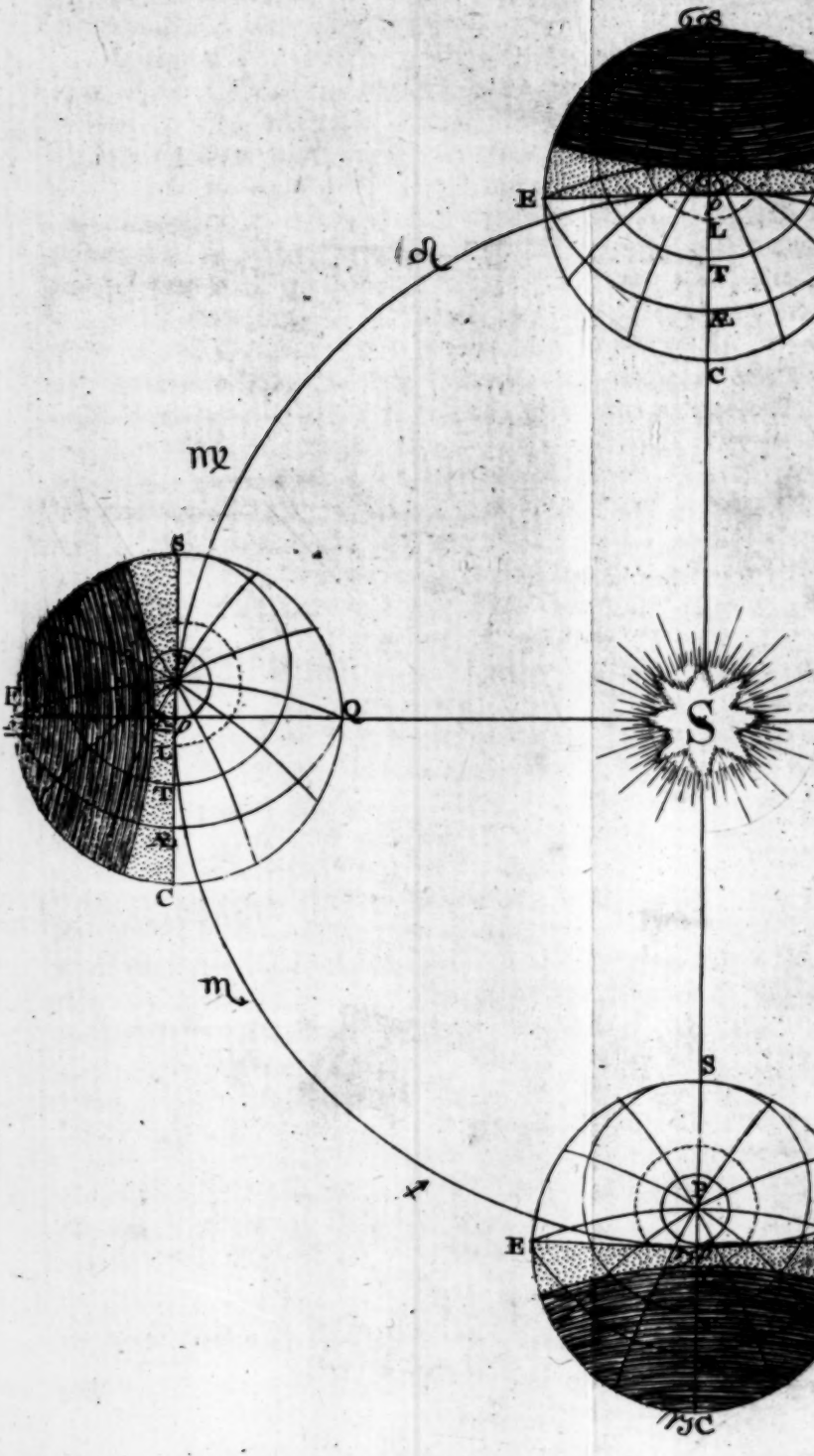
Synodical Month. which is called a *Synodical Month*; becauſe while t Moon in its proper Orbit finiſhes its Courſe, t Earth advances near a whole Sign in the Eclipt which Space the Moon has ſtill to deſcribe before ſhe will ſeen in Conjunction with the Sun.

When the Moon is in Conjunction with the Sun, note Place in the Ecliptic; then turning the Handle, we'll find th 27 Days and 7 Hours will bring the Moon to the ſame Plac and after we have made 2¼ Revolutions more, the Moon w be exactly betwixt the Sun and the Earth.

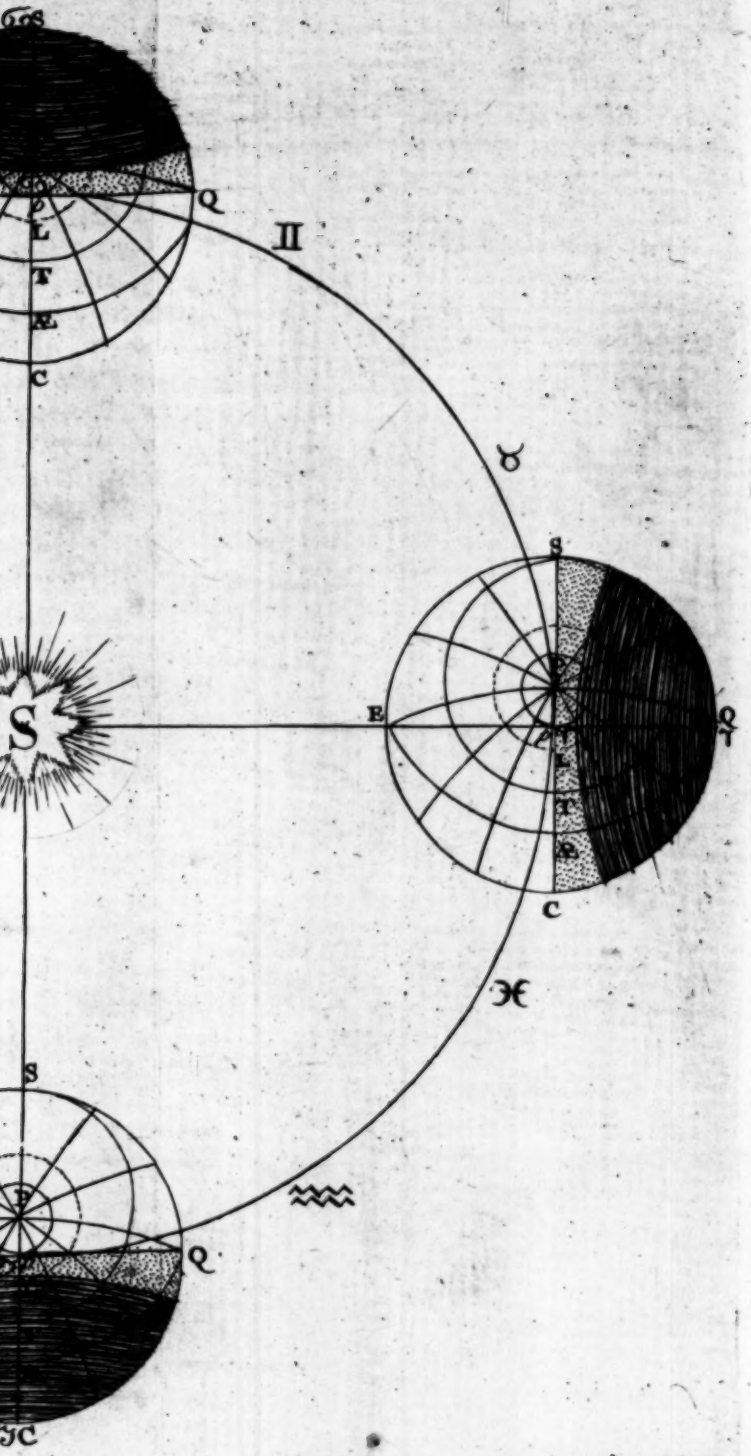
The Moon all the while keeps in her Orbit, and ſo the Wi that ſupports her continually riſes or falls in a Socket as changes her Latitude; the black Cap ſhifts it ſe

Phaſes of the Moon. and ſo ſhews the Phaſes of the Moon, according her Age, or how much of her enlighten'd Part ſeen from the Earth. In one Synodical Month t Line of the Nodes moves about 1½ Degree from *Weſt* to E and ſo makes one entire Revolution in 19 Years.

Plate VI.



fronting Page 132.



J. Grim Sc.

A B be an Arch of the Earth's Orbit, and *Plate 7. Fig. 1.*
the Earth is in T, let the Moon be in N, in
nction with the Sun in S; while the Moon is deſcribing
bit N A F D, the Earth will deſcribe the Arch of her
T *t*; and when the Earth has got into the Point *t*, the
will be in the Point of her Orbit *n*, having made one
ete Revolution round the Earth. But the Moon, before
mes in Conjunction with the Sun, muſt again deſcribe
rch *n o*; which Arch is ſimilar to T *t*, becauſe the Lines
f *n*, are parallel; and becauſe, while the Moon deſcribes
rch *n o*, the Earth advances forward in the Ecliptic; the
deſcribed by the Moon, after ſhe has finiſhed her perio-
Month, before ſhe makes a Synodical Month, muſt be ſome-
greater than *n o*. To determine the mean Length of a
ical Month; find the Diurnal Motion of the Moon, (or
ace ſhe deſcribes round the Earth in one Day) and like-
he Diurnal Motion of the Earth; then the Difference be-
theſe two Motions, is the apparent Motion of the Moon
the Earth in one Day; then it will be, As this differential
is to a whole Circle; ſo is one Day, to that ſpace of Time
in the Moon appears to deſcribe a complete Circle round
rth; which is about 29½ Days: But this is not always a
unation; for the Motion of the Moon is ſometimes faſter
metimes ſlower, according to the Poſition of the Earth
Orbit.

ne Synodical Month, the Moon has all manner of As-
with the Sun and Earth; and becauſe ſhe is opake, that
f hers will only appear bright which is towards the Sun,
the oppoſite remains in Darkneſs. But the Inhabitants
Earth can only ſee that Face of the Moon, which is turn-
wards the Earth; and therefore, according to the various
ns of the Moon, in reſpect of the Sun and Earth, we
e different Portions of her illuminated Face, and ſo a
ual Change in her * *Phaſes*.

S be the Sun, R T V an Arch of the Earth's *Plate 7. Fig. 2.*
T the Earth, and the Circle A B C D, *&c.* the
s Orbit, in which ſhe turns round the Earth, in the Space
lonth; and let A, B, C, *&c.* be the Centers of the Moon
erent Parts of her Orbit.

w if with the Lines S A, S B, *&c.* we joyn the Centers
Sun and Moon, and at right Angles to theſe, draw the
H O; the ſaid Lines H O. will be the Circles that ſeparate

ſes of the Moon, are thoſe different Appearances we obſerve in her, ac-
to her Poſition in reſpect of the Sun and Earth.

the

the illuminated Part of the Moon, from the dark and obſcu
Again, if we conceive another Line I L, to be drawn at rig
Angles to the Lines T A, T B. *&c.* paſſing from the Center
the Earth to the Moon, the ſaid Line I L will divide the vi
ble Hemiſphere of the Moon, or that which is turned towar
us, from the inviſible, or that which is turned from us; a
this Circle may be called the *Circle* of *Viſion.*

Full Moon. Now it is manifeſt, that whenever the Moon
in the Poſition A, or in that Point of her Or
which is oppoſite to the Sun, the Circle of Viſion, and t
Circle bounding Light and Darkneſs do coincide, and all t
illuminated Face of the Moon is turned towards the Earth, a
is viſible to us; and in this Poſition the Moon is ſaid to
full. But when the Moon arrives to B, all her illuminated Fa
is then not towards the Earth, there being a Part of it, HB
not to be ſeen by us; and then her viſible Face is defici
from a Circle, and appears of a gibbous Form, as in B. *Fig.*
Again, when ſhe arrives to C, the two forementioned Circ
cut each other at right Angles, and then we o

Half Moon. ſerve a *Half Moon*, as in C, *Fig.* 3. And again, t
illuminated Face of the Moon is more and mo
turned from the Earth, until ſhe comes to the Point E wh
the Circle of Viſion, and that bounding Light and Darkne
do again coincide. Here the Moon diſappears, the illumina
Part being wholly turned from the Earth; and ſhe is now ſa
to be in *Conjunction* with the *Sun*, becauſe ſhe is in the ſame D
rection from the Earth, that the Sun is in, whi

New Moon. Poſition we call a *New Moon.* When the Moon h
arrived to F, ſhe again reſumes a horned Figure; b
her Horns (which before the Change were turned Weſtwa
have now changed their Poſition, and look Eaſtward. Wh
ſhe has arrived to a Quadrat Aſpect at G, ſhe'll appear biſecte
like a Half-Moon; afterwards ſhe'll ſtill grow bigger, until
laſt ſhe comes to A, where again ſhe'll appear in her full Spl
dor.

The ſame Appearances which we obſerve in the Moon, a
likewiſe obſerved by the *Lunarians* in the Earth; our Earth b
ing a Moon to them as their Moon is to us; and we are o
ſerved by them, to be carried round in the ſame ſpace of Tim
that they are really carried round the Earth. But the ſa
Phaſes of the Earth and Moon happen when they are in a co
trary Poſition; for when the Moon is in Conjunction to
the Earth is then in Oppoſition to the Moon, and the *Lu*
rians have then a full Earth, as we in a ſimilar Poſition have
full Moon. When the Moon comes in Oppoſition to the Su
the Earth ſeen from the Moon, will appear in Conjunctio
wi

ith her, and in that Poſition the Earth will diſappear; af-
rwards ſhe'll aſſume a horned Figure, and ſo ſhew the ſame
haſes to the Inhabitants of the Moon, as ſhe does to us.

Of the Eclipſes of the Sun and Moon.

An *Eclipſe* is that Deprivation of Light in a Pla- *Eclipſe.*
t, when another is interpoſed betwixt it and the
n. Thus, an Eclipſe of the Sun is made by the Interpoſiti-
of the Moon at her Conjunction; and an Eclipſe of the
oon is occaſioned by the Shadow of the Earth falling upon the
oon, when ſhe is in Oppoſition to the Sun.

Let S be the Sun, T the Earth, and A B C its Sha- *Fig. 4.*
w; now if the Moon, when ſhe is in Oppoſition
the Sun, ſhould come into the conical Space A B C,
'll then be deprived of the Solar Light, and ſo *Lunar*
dergo an Eclipſe. *Eclipſe.*

In the ſame manner when the Shadow of the Moon falls up-
the Earth (which can never happen but when the Moon is
Conjunction with the Sun) that part upon which the Sha-
w falls, will be involved in Darkneſs, and the Sun
lipſed. But becauſe the Moon is much leſs than *Solar*
e Earth, the Shadow of the ☽ cannot cover the *Eclipſe.*
ole Earth, but only a part of it. Let S be the *Fig. 5.*
n, T the Earth, A B C the Moon's Orbit, and L
e Moon in Conjunction with the Sun: Here the Shadow of
e Moon falls only upon the part D E of the Earth's Surface,
d there only the Sun is entirely hid; but there are other
rts E F, D G, on each ſide of the Shadow, where the Inha-
tants are deprived of part of the Solar Rays, and that more
leſs according to their Diſtance from the Shadow. Thoſe
o live at H and I, will ſee Half of the Sun Eclipſed: but
the Spaces F M, G N, all the Sun's Body will be viſible with-
t any Eclipſe. From the preceding Figure, it appears, that
Eclipſe of the Sun does not reach a great way upon the Su-
ficies of the Earth: but the whole Body of the Moon may
metimes be involved in the Earth's Shadow.

The ☽ alſo being an opake Body, and enlightned by the ☉
nſequently caſts a Shadow towards thoſe parts that are turn-
from the ☉, and if the Earth ſhould be deprived of the ☉'s
ht, by being immers'd in the ſhadow of ☽ this Phænomena
ght to be call'd an Eclipſe of the Earth; but the Obſerver of
being on the Earth, and the ☽ (which more or leſs covers
e ☉) not being eaſily perceiv'd by us: the Defect of Light ap-
ars to us as in the ☉ it ſelf, and is therefore call'd an Eclipſe

of

of ☉, which is diſtinguiſh'd into a Total Eclipſe, wherein ☽ covers the whole body of the ☉ from us, or a partial Eclipſe wherein the ☽ covers only a part of the ☉.

But it is to be obſerved, that altho' an Eclipſe ☉ be in reality an Eclipſe of the Earth, yet what is call'd a total Eclipſe of the ☉ is not to be conceiv'd in reality as a total Eclipſe of the Earth, or that the whole upper and oppoſite Hemiſphere of the Earth is then deprived of the Sun's Light, as in a total Eclipſe of ☽ its whole oppoſite Hemiſphere is darkned; (the reaſon of which difference is this) the Earth being bigger than the ☽, the Cone of its Shadow is big enough to involve the whole oppoſite Hemiſphere of ☽ in its darkneſs; whereas the ☽ being leſs than the Earth the Cone of her Shadow will involve at once only a ſmall tract.

Although the Moon ſeen from the Earth, and the Earth ſeen from the Moon, are each alternately once a Month in Conjunction with the Sun; yet by Reaſon of the Inclination of the Moon's Orbit to the Ecliptic, the Sun is not Eclipſed every New Moon, nor the Moon at every Full. Let T be the Earth, D T E an Arch of the Ecliptic, A L B F the Moon's Orbit, having the Earth T in the Center; and let A G B C be another Circle coinciding with the Ecliptic, and A, B, the Nodes, or the two Points where the Moon's Orbit, and the Ecliptic cut each other: A the aſcending Node, and B the deſcending Node. The Angle G A L equal to G B L is the Inclination of the Moon's Orbit to the Ecliptic, being about 5¼ Degrees. Now a Spectator from the Earth at T, will obſerve the Sun to move in the Circle A G B C, and the Moon in her Orbit A L B F; whence it is evident, that the Sun and Moon can never be ſeen in a direct Line from the Center of the Earth, but when the Moon is in one of the Nodes A or B; and then only will the Sun appear centrally Eclipſed. But if the Conjunction of the Moon happens when ſhe is any where within the Diſtance A *c* of the Nodes either *North* or *South*, the Sun will be then Eclipſed, more or leſs according to the Diſtance from the Node A, or B. If the Conjunction happens when the Moon is in *b*, the Sun will be then one half Eclipſed; and if it happens when ſhe is in A, the Moon's Limb will juſt touch the Sun's Diſk, without hiding any part of it. *Fig. 6.*

If the *Lunar* Orbit coincided with the Ecliptic, every Lunation would exhibit two Eclipſes one of the ☉, the other of the ☽ the former at the New ☽ the other at the full ☽; ſo that there would be no New ☽ nor full without an Eclipſe; and not only ſo, but theſe Eclipſes would be both of them Total and Central. Nay the ſame Numbers which would have ſhew

true Conjunctions, and Oppoſitions would have ſhew'd Eclipſes alſo.

But from conſidering the Annual Motion of the ☉ and the Angle which the Moons Orbit makes with the Ecliptic 'tis manifeſt there cannot be an Eclipſe at every Change or Full; becauſe the Earth and the Earth's Shadow always falls in the plane of the Ecliptic; ſince both ☉ and Earth are always there, theſe Effects or Eclipſes only can happen when the true Conjunctions or Oppoſitions are found in or about the Nodes, that is, when the Conjunctions are within 16°. 26' and the Oppoſitions are within 12°. 34' of either Node before or after.

The Shadow of the Earth at the Place where the Moon's Orb intерſects it, is three times as large as the Moon's Diameter, as in *Fig.* 4. and therefore it often happens that Eclipſes of the Moon are Total, when they are not Central: and for the ſame Reaſon the Moon may ſometimes be totally eclipſed for three Hours together; whereas Total Eclipſes of the Sun can ſcarcely ever exceed four Minutes.

In Total and Central Eclipſes of the ☽ the Duration is found to be ſo long, as to let the ☽ go the Length of three of its Diameters in the Shadow totally eclipſed; which ſtay in the Earth's Shadow is computed to be about four Hours whereof the ☽ takes one Hour from its beginning to enter the Shadow till quite immerſed therein; two Hours more ſhe continues totally Datk, and the fourth Hour is taken up from her firſt beginning to come out of the Shadow, till ſhe is quite out of it: but the Eclipſe of the ☉ laſts not ſo long, its ſeldom in any one place exceeds 2¼ Hours, and in total Darkneſs, never above 5 Minutes, ſcarce 2 or 3 ſuch will happen in the Compaſs of an Age; becauſe the point of the ☽'s Shadow reaches but a little beyond the Earth, and ſometimes does not reach the Earth at all; alſo the apparent Diameter of the ☽ does very little exceed the apparent Diameter of the ☉, that leſs it be in central Eclipſes. which are rare and unuſual, the ☽ cannot wholly cover and hide the Body of ☉ from us.

The Eclipſes of the Sun and Moon are very well explained by the *Orrery*: thus, Having put the Lamp in the Place of the ☉, and the little Earth and the little Moon in their proper Places, inſtead of the larger ones; let the Room wherein the Inſtrument ſtands be darkned; then turning the Handle about, you'll ſee when the Conjunction of the Moon happens. When ſhe is in or near one of the Nodes, her Shadow will fall upon the Earth, and ſo deprive that part upon which it falls of the Light of the Sun: If the Conjunction happens when the Moon is not near one of the Nodes, the Light of the Lamp will fall upon the Earth, either above or below the Moon, accord-

ing to her Latitude at that Time. In like manner, when t
full Moon happens near one of the Nodes, the Shadow of t
Earth will fall upon the Moon; and if the Moon's Latitu
be but small, her whole Face will be involved in Darkne
At other times, when the full Moon happens when she is n
near one of her Nodes, the Shadow of the Earth will pass e
ther above or below the Moon, and so by that means
Moon will escape being eclipsed.

T H

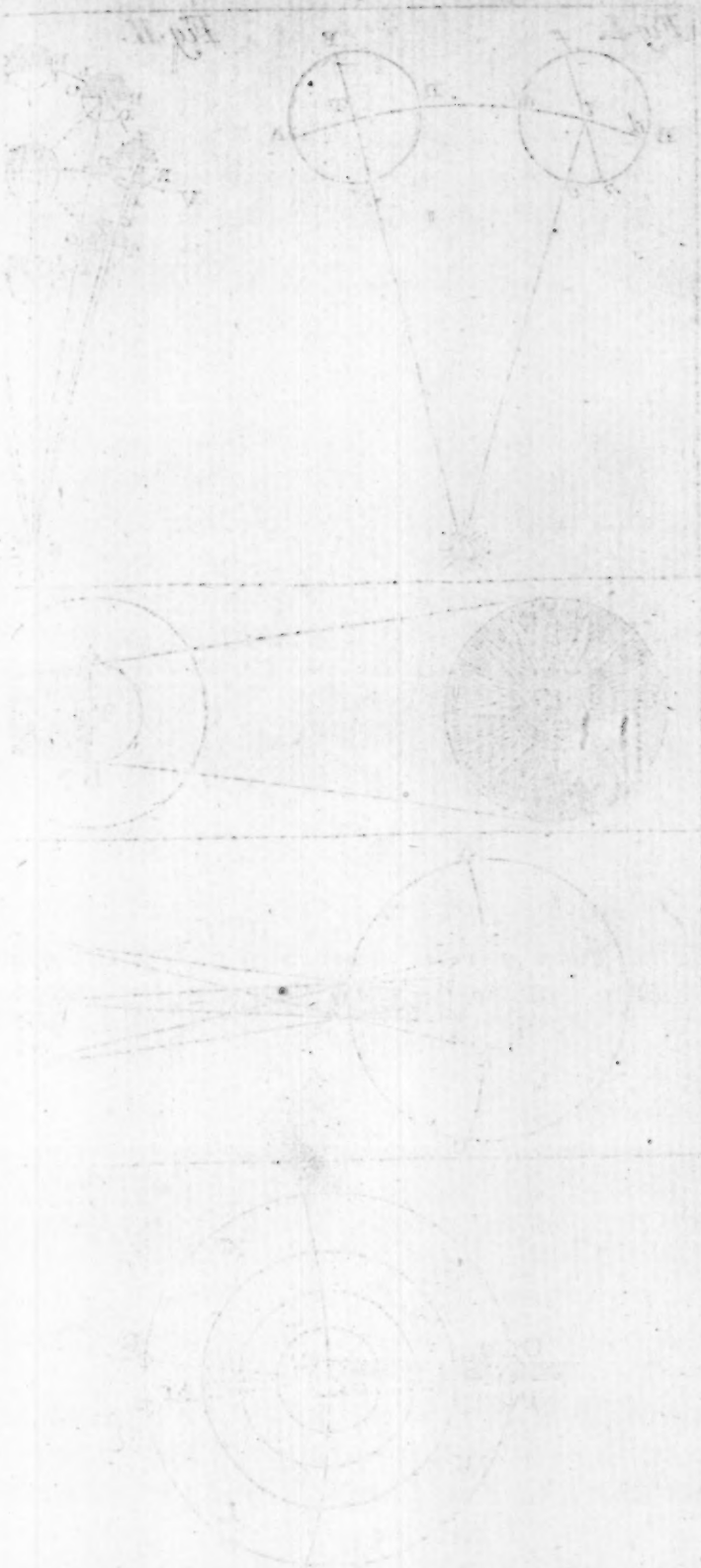


Plate VIII.

Fig. I.

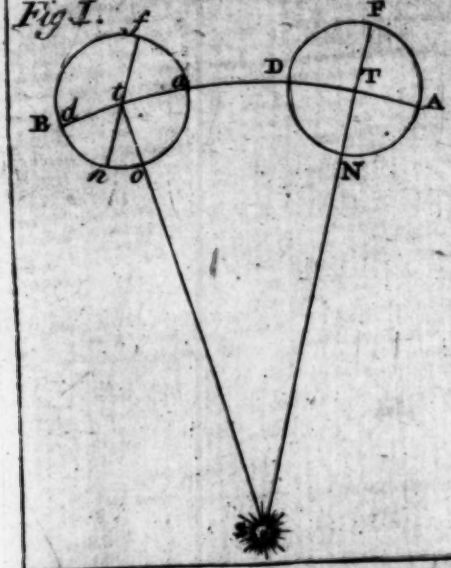


Fig. II.

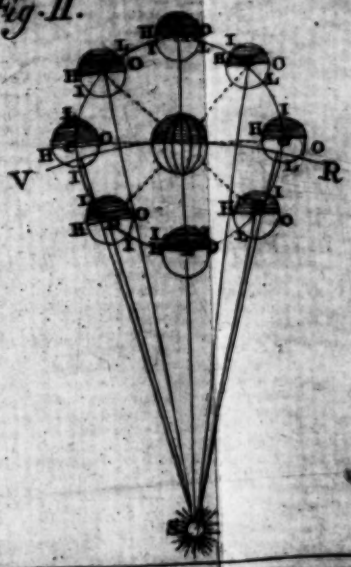


Fig. IV.

Fig. V.

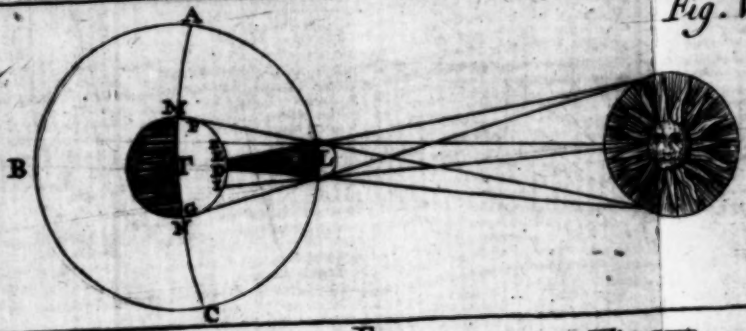
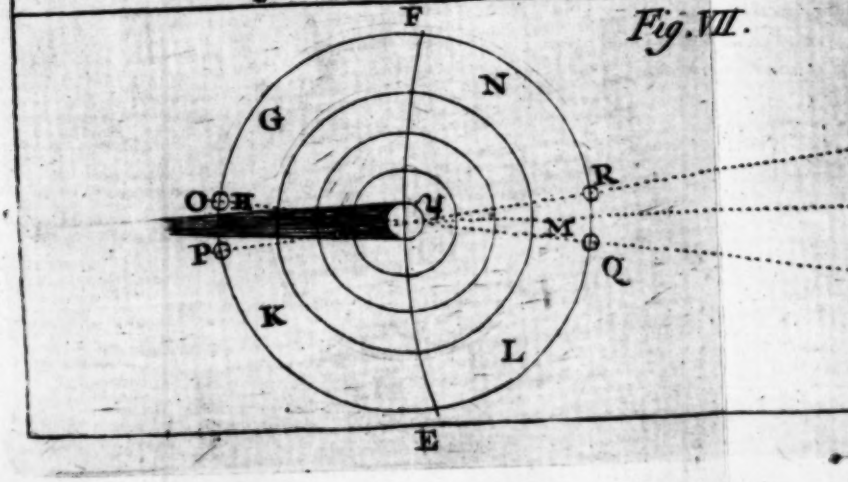
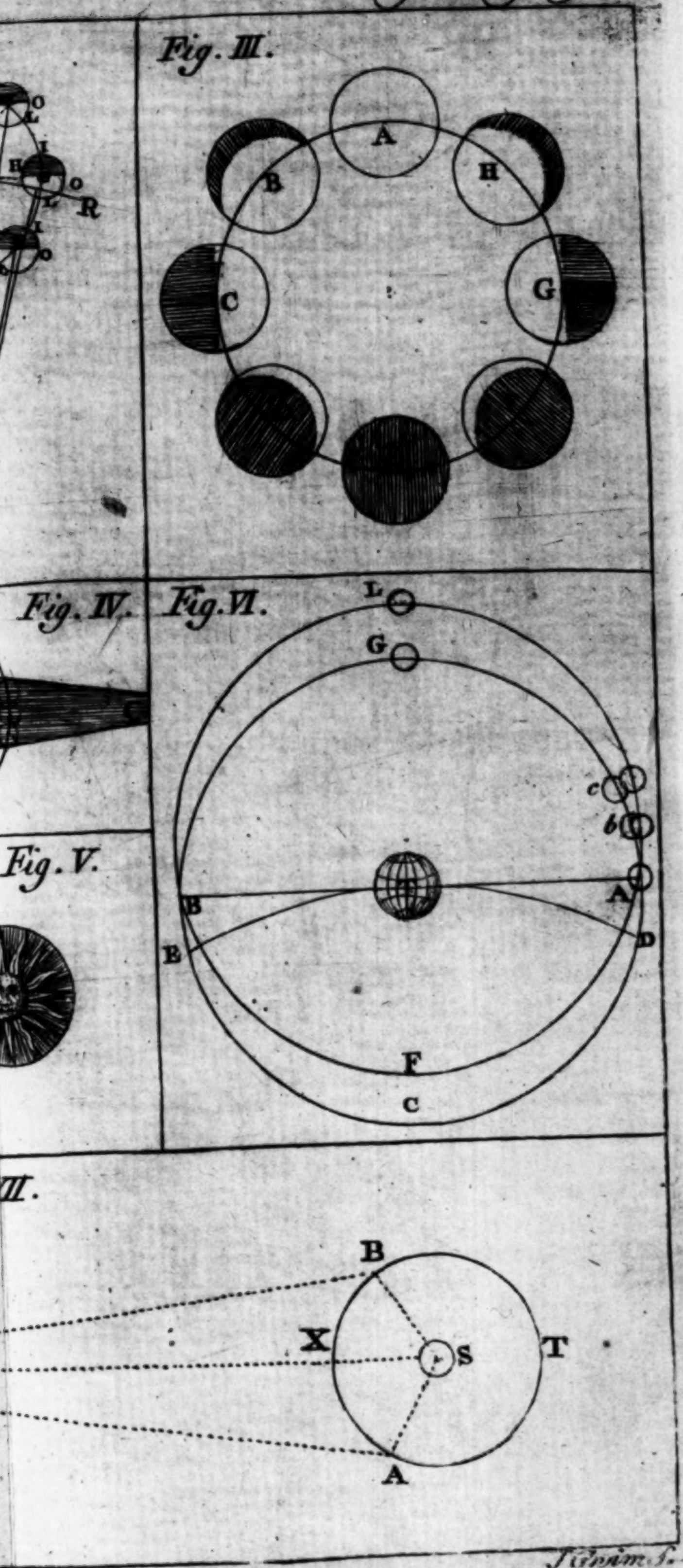


Fig. VII.



fronting Page 138



THE
DESCRIPTION *and* USE
OF
TELESCOPES.

SECT. I.

THE Sight of Man is of it ſelf confined to nar-row Views, and tho' it takes in a great Part of the Creation at once, yet all is repreſented in Miniature and imperfectly. The naked Eye ſees only ſo much of external Objects, as is ſufficient to move the principal Paſſions, and give notice t more immediately concerns the Safety and Happineſs Animal. What is more than this, was left as a Subject r Curioſity, upon which we might exerciſe thoſe Facul-ich are beſtowed by our bountiful Benefactor, for this nd, of ſearching into the aſtoniſhing Mechaniſm of all orks, and from thence enlarging our Idea of his Great-Objects placed at a great Diſtance whether upon the Sur-the Earth, or in the Heavens are ſeen under ſo ſmall gle, that their parts are not to be diſtinguiſhed one nother; and by this means thoſe diſtant charming Scenes re were hid from us, which the Study of *Catoptrics* and *Diop-* ſince laid open to our View. This noble part of Know-eaches us how by a due Poſition of Glaſſes ground into Figures, we may enlarge the Diameter of the Heavenly , and all ſuch *Objects*, to which we are allow'd no nearer ch, in what Proportion we pleaſe, and view them as per-

fectly and distinctly as if we could summon them before
and command them to the End of our Telescope: This
brought us into a perfect Acquaintance with these surprizi
Parts of the Creation, which are far separate from this Glo
of ours, and with which we are allow'd no Commerce, b
Looking. We can now perceive the Sun to be a vast Globe
Fire, and by the different *Phases* of all the *Planets*, that he is t
Fountain of all their Light. The Surfaces of most of them
pear like so many *Maps* of Land and Water, and there are fi
now but allow both them and the *fixed Stars*: some nobler
than to twinkle upon us in the Night. By fixing upon some
markable *Spots* upon their Surfaces, and observing how th
shift their Position, and in what time they again return
the same Place, we determine the Motion of these Bodies rou
their *Axis*, and the time in which that Revolution is perform
Several *Secondary Planets* or *Satellites*, which were too small for
naked Eye, are now discern'd to move round *Jupiter* and *Sa*
as the Moon round our Earth; and about the last of them
seen the particular Phænomenon of an *Annulus* or *Ring*: N
is the Discovery of these *Satellites*, meerly Speculative, but
prodigious Use and Advantage for their *Eclipses* have determi
the *Velocity* of Light and are so frequent, as to be the most co
stant Appearance the Heavens afford us at present for the So
tion of the Great, and Valuable Problem of the *Longitude*. T
Distances, Magnitudes and Motions of all the Heavenly Bod
and even the Irregularities of the ☽, have by this means be
so nicely observ'd, and by the Power of Numbers, reduc
within some few Tables for common and easy Use that th
Places for any determinate instant of Time to come, are n
to be predicted as easily, and almost as exactly as we cou
wish.

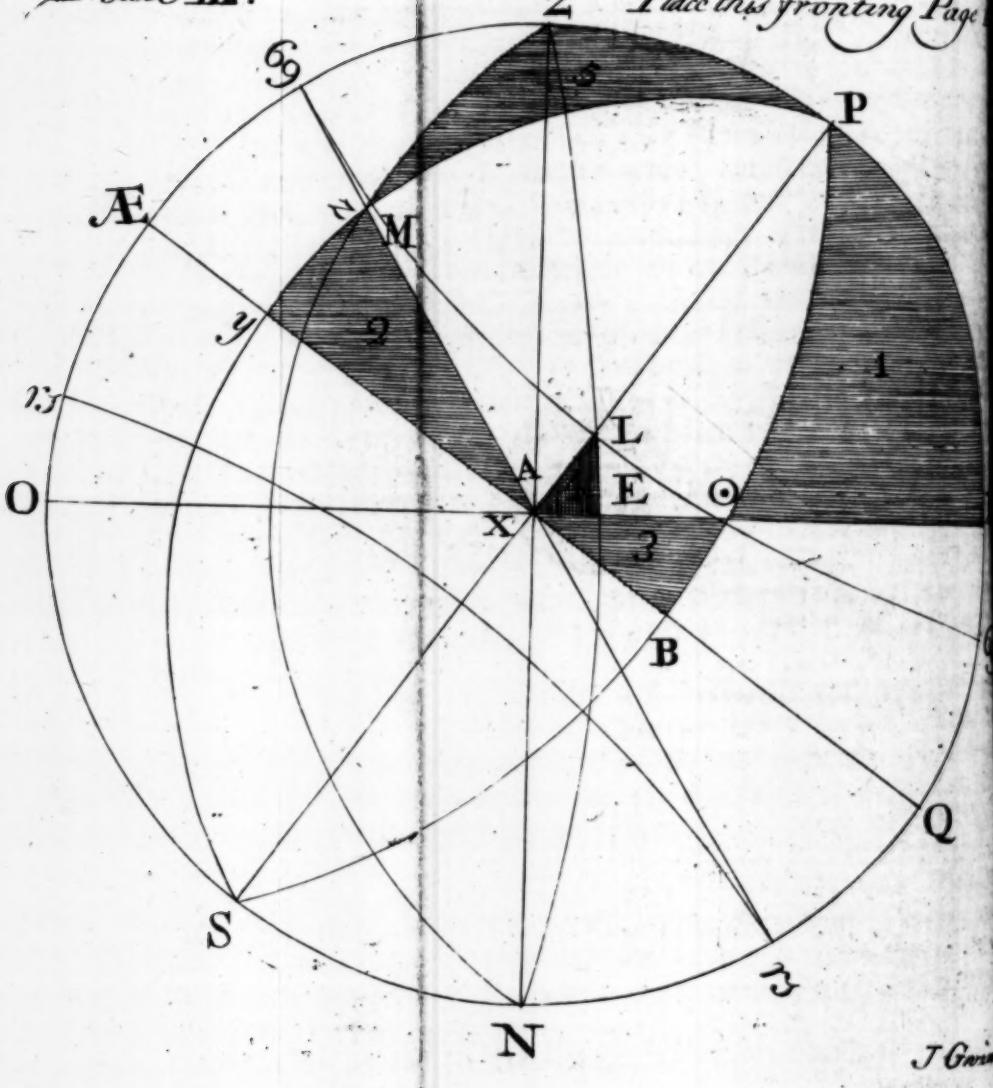
Galileus a *Florentine*, about 1615 first invented and applied t
Telescope, to the Discovery of Celestial Objects; by which
beheld the 4 Moons or Satellites of ♃ the different Phases
♄, and the increase and decrease of ♀, that the ☽'s Disk w
like our Earth rising with Mountains, and depress into Valle
and Seas; that the ☉ had his Spots whereby he evinced its R
tation upon its own Axis, and that the *Via Lactea* was nothi
but a multitude of small Stars all of the same sort or kind, a
since his time both *Astronomy* and *Geography* have from th
Glasses received many particular Advantages, and Discover
unknown to the Antients.

For by the means of Telescopes, especially such as magni
the Diameters of Objects 100 or 200 times we will see the ☽
the same Manner Figure and Bigness, as it would appear in
a Distance 100 or 200 times less than ours; by the same we m
asce


BRITISH MUSEUM
15
GB
FEB

Plate III.

Place this fronting Page



ſcend yet higher, and approach the Planets, Comets, and ixed Stars, ſo near, that of ſuch immenſe Diſtances, there re-nains only the hundredth, or two hundredth part to have he whole Journey finiſhed, and from thence we can behold the Converſion of the Planets about their proper Axes. The Moons of ♃ and ♄ their Eclipſes the Belts of ♃ the wonderful Ring of ♄, and all the various Appearances and ſhapes it takes. This s the chief Inſtrument, by which we obſerve the Magnitude nd apparent Motions of the Heavenly Bodies, and hence their roportional Diſtances are calculated.

'Tis now reckon'd no abſurd Notion to conceive the *fixed tars*, as ſo many Suns; probably at as great Diſtances one from nother, as they are from us and every one their Syſtem of in-abited Planets circling round them. And perhaps the Number of thoſe we ſee may bear little or no Proportion to thoſe others hat may be diſperſed thro' the vaſt Regions of the *Univerſe* at uch Diſtances from our little *Ball*, that no Aſſiſtance can ever elp us to a ſight of them. A Notion that gives, ſurely the noſt juſt and noble Sentiments, that the Mind of Man can en-ertain of an Almighty Author. That the *Milky-Way* in the Heavens, which we behold in a clear Star-light Night, is nothing elſe, but a continued Cluſter of ſuch *fixed Stars* (as aforeſaid,) is a ruth of which we are aſſured by the Teleſcope; and to the ſame Help it is we owe all we know of theſe Heavenly bodies call'd *Comets*; their Diſtance, Magnitude and Motion round the *Sun*, n ſuch *eccentrical Orbits*, as ſome of them come very near to ight Lines. To what a ſurprizing heighth this *Cometical Aſtronomy* as been carried by the preſent Age, notwithſtanding the Ob-ervations we have been able to make upon theſe Bodies are o few, and thoſe made by our Predeceſſors ſo imperfect, may e ſeen in the Writings of thoſe incomparable Aſtronomers, Sir *Iſaac Newton*, Doctor *Gregory*, and Doctor *Halley*: That in every clear Morning and Evening, we ſee the *Sun* for ſome time before he iſes, and after he ſets is a *Paradox* only to be unridled by *Dioptrics*; and if we would know the true Place of any Heavenly Body, elevated not many degrees above the *Horizon*, the ſame Science tells us, that here, *Seeing is not Believing*. but that we muſt correct our *Eye-Sight* by a Table of *Refractions*. It is true, the *Ratio* of *Refraction* of the *Atmoſphere* very near the *Horizon*: does not obſerve a conſtant Rule; becauſe there happens a very great Variety in the Accumulations of Vapours about theſe Parts: But then this Variation depends pretty regularly upon the Poſition of the *Sun*, above or below the *Horizon*, and the dif-ferent State of the Weather, and if in the Morning or Evening we ſee the lower parts of a diſtant Tower or Mountain, thro' a Teleſcope fixed in Poſition, we ſhall find the upper parts of the

the ſame Tower or Mountain in the ſame Place, if our Obſervations be made nearer Noon, and juſt at Noon, the ſame Object will be ſeen loweſt of all, as the accurate *Huigens* has obſerv'd; and this Difference is greater in cold, and moiſt than in hot and dry Weather, and tho' not in a Proportion always certain, yet conſtant enough for Phyſical Purpoſes. In ſhort, without the Aſſiſtance of *Teleſcopes*, *Aſtronomy* could have come to nothing, and our Obſervations on the Heavens, had gone little further than foretelling a fine Morning from the ſetting of the *Sun*; or a Shower of Rain from the Courſe of the Clouds.

II. *Of the Conſtruction of the* Aſtronomical TELESCOPE.

A Teleſcope is an Optic Inſtrument which ſerves to diſcover Objects at a Diſtance; the Invention of which is one of the nobleſt and moſt uſeful theſe Ages have to boaſt of: By Means hereof the Wonders of the Heavens are diſcover'd to us, and Aſtronomy brought to a Degree of Perfection, which former Ages could have no Idea of. The Optic Principles, whereon Teleſcopes are founded, are contain'd in *Euclid*, and it is for want of Attention thereto, that the World was ſo long without that admirable Invention; as no doubt there are a great many others lying hid in the ſame Principles, only waiting for Reflection or Accident to bring them forth.

Teleſcopes are either *Refracting* or *Reflecting*. *Refracting Teleſcopes* are of ſeveral Kinds, and are diſtinguiſhed by the Number and Form of their Lens's or Glaſſes, and denominated from their particular Uſes, *&c.* Such are the Terreſtrial or Land Teleſcope, and Cœleſtial or Aſtronomical Teleſcope.

If a Teleſcope conſiſts only of a Convex Object Lens, and an Eye-Glaſs of a much greater Convexity than the Object-Glaſs is, then will the apparent Magnitude of the Object ſeen through that Teleſcope, be to the Object ſeen by the naked Eye at the Station of the Object-Glaſs, as the Focal Length of the Object-Glaſs to the Focal Length of the Eye-Glaſs. Thus in Plate 8. Fig. 1. let A B repreſent the Object-Glaſs, and ſuppoſe its Focal Length H d 12 Foot or 144 Inches, and the Eye-Glaſs repreſented by c D, its Focal Length 3 Inches; then the apparent Diameter of the Object, ſeen through ſuch a Teleſcope to that ſeen through the naked Eye, will be as 144 to 3, or as 48 to 1, wherefore ſuch a Teleſcope will be ſaid to Magnify 48 times, and its Surface 2304 times (*i. e.* the Square of 48).

Wherefore

Wherefore if the ſame Object-Glaſs be combined with an Eye-
aſs whoſe Focal Diſtance is 1, and at another time with an
e-Glaſs whoſe Focal Diſtance is 2, the former Teleſcope will
gnify twice as much as the latter. Alſo, if two Teleſcopes
ve different Lengths, and the Focus of the Eye-Glaſs of the
orter be in the ſame Proportion to the Focus of its Object-
aſs, as the Focus of the Eye-Glaſs of the longer bears to its
ject-Glaſs; then thoſe two Teleſcopes will *magnify alike*. But
long Teleſcopes are of very great Uſe, and it is impoſſible
make ſhort ones perform as well: For,

1. Object-Glaſſes of a ſhorter Focus will not bear Eye-Glaſſes
oportionably ſhort without colouring the Object, or ren-
ing it dark and obſcure.
For Inſtance: Suppoſe a very good 12 Foot Object-Glaſs will
ceive an Eye-Glaſs of no ſhorter Focus than 3 Inches, with
arneſs and *Diſtinctneſs*, yet, however, an Object-Glaſs of 24 Foot
cus, equally good, will bear an Eye-Glaſs of leſs than 6
ches Focus, (perhaps of 4 or 5 Inches Focus) with equal *Clear-*
ſs and *Diſtinctneſs*; and then, tho' an Object-Glaſs of 12 Foot,
ith an Eye-Glaſs of 3 Inches, will magnify but 48 times, as
above proved, yet an Object-Glaſs of 24 Foot, with an Eye-
aſs of 4 Inches, will magnify 72 times, which is above one
hird more than the former.

2. The Image of the Moon, or any other Object, in the di-
inct Baſe of an Object-Glaſs of 24 Foot, is twice as long as
e Image of the diſtinct Baſe of an Object-Glaſs of 12 Foot;
nd conſequently the Image in the former will be much more
ain and diſtinct. Hence may be concluded alſo, that if the
bject-Glaſs be formed on a leſs Sphere than an Eye-Glaſs, the
ppearance of Objects will be diminiſhed in the aforeſaid Pro-
ortion; as is plain by the Caſe, when a Teleſcope is inver-
ed. But for a more particular Conſtruction of the ſame Te-
eſcope, let A B as before (Plate 8. Fig. 1.) repreſent the Con-
ex Glaſs next the Object C D, the other Glaſs more Convex
ear the Eye. Suppoſe the Object-Glaſs A B to form the I-
age of the Object at E F, ſo that if a Sheet of White Paper
ere to be held in this Place, the Object would appear. Now
uppoſe the Rays, which paſs the Glaſs A B, and are united a-
out E F, to proceed to the Eye-Glaſs C D, and be there re-
racted: Three only of theſe Rays are drawn in the Figure;
hoſe which paſs by the Extremities of the Glaſs A B, and that
hich paſſes its Middle. If the Glaſs C D be placed at ſuch a
iſtance from the Image E F, that the Rays, which paſs by the
oint F, after having proceeded through the Glaſs diverge ſo
much,

much, as the Rays do that come from the Object, which is ſuch a Diſtance from the Eye as to be ſeen diſtinctly; theſe ing received by the Eye, will make on the Bottom of the E a diſtinct Repreſentation of the Point F. In like manner Rays, which paſs through the Object-Glaſs A B to the Point after proceeding through the Eye-Glaſs C D, will, on the B tom of the Eye, make a diſtinct Repreſentation of the Poin but if the Eye be placed where theſe Rays, which proceed fr E, croſs thoſe which proceed from F, the Eye will receive diſtinct Impreſſion of both theſe Points at the ſame time, conſequently will alſo receive a diſtinct Impreſſion from the intermediate Parts of the Image E F; that is, the Eye ſee the Object, to which the Teleſcope is directed, diſtinct The Place of the Eye is about the Point G, where the R H E, H F croſs, which paſs through the Middle of the Obj Glaſs A B to the Points E and F, or at the Place where Focus would be formed by Rays coming from the Point H, refracted by the Glaſs C D. To judge how much the Inſtr ment magnifies any Object, we muſt firſt obſerve, that the A gle under E H F, in which the Eye, at the Point H, would the Image E F, is nearly the ſame as the Angle, under wh the Object appears by direct Viſion; but when the Eye is G, and views the Object through the Teleſcope, it ſees ſame under a greater Angle; for, the Rays, which coming fr E and F croſs in G, make a greater Angle than the Rays whi proceed from the Point H to theſe Points F and E. The A gle at G is greater than that at H in the Proportion, as Diſtance between the Glaſſes A B and C D is greater than Diſtance of the Point G from the Glaſs.

This Teleſcope inverts the Object; for the Rays, which co from the Right Hand Side of the Object, go to the Point E Left Side of the Image, and the Rays, which come from Left Side of the Object, go to F the Right Side of the Ima Theſe Rays croſs again in G, ſo that the Rays, which co from the Right Side of the Object, go to the Right Side of Eye; and the Rays from the Left Side of the Object go to Left Side of the Eye; therefore, in this Teleſcope, the Im in the Eye has the ſame Situation as the Object; and ſeem that in direct Viſion the Image in the Eye has an inverted tuation, here, where the Situation is not inverted, the Obj muſt appear ſo. This is no Inconvenience to Aſtronomers Cœleſtial Obſervations, but for Objects here on the Earth is uſual to add two other Convex-Glaſſes, which may turn Object again, as is repreſented in Plate 8. Fig. 2. of thi uſe the other kind of Teleſcope, with a concave Eye-Glaſs

III.

II. *Of the Conſtruction of a* Land *or* Day TELESCOPE.

A Land or Day Teleſcope conſiſts of more than two Lens's, commonly of a Convex Object Glaſs, and three Convex Eye-Glaſſes, by which it exhibits Objects erect: The Conſtruction of it, thus.

Having provided a Tube, fit in an Object-Glaſs, which is either Convex on both Sides, or Plano-Convex, and a Segment of a large Sphere: To this add three Eye-Glaſſes, all Convex on both Sides, and Segments of equal Spheres, diſpoſing them in ſuch manner as that the Diſtance of any Two may be the Sum of the Diſtances of their Foci: Then will an Eye, applied to the leaſt Lens, at the Diſtance of its Focus, ſee Objects very diſtinctly erect and magnified in the Ratio of the Diſtance of the Focus of one Eye-Glaſs, Plate 8. Fig. 1. to the Diſtance of the Focus of the Object-Glaſs.

For 1. The Rays falling upon the Object-Glaſs parallel, the Image of the Object will be repreſented inverted at the Diſtance of the principal Focus; wherefore, ſince this Image is in the Focus of the firſt Eye-Glaſs, the Rays, after a ſecond Refraction, will become parallel, and thus falling on the third Lens, after a third Refraction, they exhibit the inverted Image invertedly, that is, a direct Image of the Object: Since then this Image is in the Focus of the third Eye-Glaſs, the Ray, after a fourth Refraction, will become Parallel, and in this Diſpoſition the Eye will receive them, and conſequently there will be diſtinct Viſion, and the Object will appear erect.

Or as *Molineux* obſerves, *p. 206 Dioptrics*. That *one* Convex-Glaſs, that is the Object-Glaſs as poſited in this Teleſcope *inverts*: The 2*d*, that is the *firſt* Eye-Glaſs does nothing towards *erecting* or *reverſing*; but repreſents the Image, as it is in the *diſtinct Baſe* of the Object-Glaſs before it, that is *inverted*. The 3*d*, Glaſs *erects*, or rather reſtores what was before *inverted*. The 4*th*, repreſents the Image as it receives it from the *diſtinct Baſe* of the 3*d*, that is erect; becauſe it inverts in the 3*d*, what was inverted in the firſt.

The Rays of Viſion meeting in a Point before they reach the Retina in the Bottom of the Eye cauſe a *confuſed* Viſion, the Fault of ſuch, as are *Purblind*, which is help'd by Concave-Glaſſes, or by holding the Object very near.

On the contrary, the Eyes of Old Men, have their Chryſtalline too flat, and cannot correct the Divergence of the Rays to make them meet on the Retina; but beyond the Eye, where,

fore, for their help, 'tis requiſite they add the adventitio Convexity of a Glaſs, that both it, and the Chryſtalline tog ther may be ſufficient to make the Rays meet juſt at the Retin and from thence it appears, that Spectacles help Old Men, not b magnifying an Object; but by making its Appearance *diſtinct*: fo Old Perſons cannot read the largeſt Print without Spectacle and yet with Spectacles they read the ſmalleſt, tho, the with Spectacles do not appear ſo large, as thoſe without Sp ctacles.

IV. *To Know whether Glaſſes be Plane or Spherical.*

Shake them ſomewhat nimbly, between the Eye and Obje and if the Object ſeem to move by the Motion of the Gla the Glaſs is not plane, the reaſon hereof is this, that towar the Extremities of a Glaſs, it refracts more than towards t Middle, and that Glaſs, which makes the Objects ſeem the mo to move is form'd on the Leſs Sphere, whether Conver Concave.

V. *To Combine, or put together a* TELESCOP *of four Glaſſes.*

Take the 2 Firſt Eye-Glaſſes, and Combine them by Tryal ſo as to make a diſtinct inverting Teleſcope.

Then take the Object-Glaſs, and firſt Eye-Glaſs, and by Tryal combine them likewiſe.

Laſtly, take both theſe Teleſcopes, and without altering t Diſtances of their Glaſſes in either of them ſingly by Tryal combine both theſe Teleſcopes, till the Appearance be cl and diſtinct.

What is here done by Tryals, may be effected by actual Mea ſuration or deſigning out the Diſtances of the Glaſſes fro each other by knowing their Focal Lengths.

VI. *To find the Foci of Glaſſes.*

If of pretty deep Convexities, apply them to the End of Scale of Inches and Parts, and expoſe them before the Sun, an upon the Scale we ſhall find the bright Interſection of the Ra exactly meaſur'd out. Or expoſe them in the Hole of a da Chamber, and where a white Paper receives the *diſtinct* Repre ſentation of diſtant Objects, there is the Focus of this Gla This is an univerſal and certain way for all Convexes.

VII. *The Wonderful Painting by means of an Object-Glass.*

Make choice of a Room with a *North* Window so darkn'd, as to admit no Light to come in, save at the Hole, wherein fix the Object-Glass of a seven Foot Telescope, behind which let no Glass be, then in the dark Room move a Sheet to and fro, till you find the Out-Object appear *distinct*, there fasten it to the Cieling then will whatever is without the Hole be represented on that Sheet, with such exquisite Exactness, as far surpasses the utmost skill of any Painter to express; for if the Sun shine brightly upon the Objects, we'll have the Color of all things there in their natural Paint, and such an admirable Proportion of Light and Shadow, as is impossible to be imitated by Art.

N.B. Let not the Sun Shine near the Hole, else all will appear confused. Hereby their Motion is represented, as well as Color and Proportion, Postures, Gestures, as lively on the Cloth, as to any ones Eye without, only they will be all inverted, which to rectify, Hold a Looking-Glass over against the Sheet, with an acute Angle to your Breasts, and look down into it, and all things appear Natural and Erect, like so many Walking and Magical glaring Spectres.

VIII. *That Light is a Body.*

First appears, by this Affection of being Refracted, and that in its passage thro' this, and 'tother Diaphanous body, it does find a different Resistance, now 'tis unconceivable, how any thing but Body, should suffer Resistance; because Resistance must proceed from contact of two Bodies, and contact either Active or Passive, belongs only to Body according to that of the Philosophic Poet, (*Lucretius*) *Tangere enim & tangi nisi Corpus nulla potest res.* 2*dly*. It requires Time to move from one place to another, and does not in an Instant; but is only of all Motions, the quickest, requiring about 7 min. to pass from the Sun to us. 3*dly*, Light cannot by any Art, or Contrivance whatsoever, be encreased or diminished, (that is to say) we cannot Magnify, or Instance, the Light of the Sun or a Candle, no more than we can magnify a Cubic Inch of Gold, or make it more than a Cubic Inch. But whenever we see Light increased 'tis by robbing of some other part of the Medium of 'its Light, or by bringing the Light that naturally should have been diffused thro' some other part to the more enlightned Place.

The Focal Distance of the Object *Lens*, or the Length of the *Telescope*.	The Diameter of the Aperture of the Object *Lens*.	The Focal Distance of the Ocular *Lens*.	The Proportion of Magnifying, consider'd as to Diameter.
Rhinland Feet.	*Inches, & Decimals.*	*Inches, & Decimals.*	
1.	0,55.	0,61.	20.
2.	0,77.	0,85.	28.
3.	0,95.	1,05.	34.
4.	1,09.	1,20.	40.
5.	1,23.	1,35.	44.
6.	1,34.	1,47.	49.
7.	1,45.	1,60.	53.
8.	1,55.	1,71.	56.
9.	1,64.	1,80.	60.
10.	1,73.	1,90.	63.
13.	1,97.	2,17.	72.
15.	2,12.	2,33.	77.
20.	2,45.	2,70.	89.
25.	2,74.	3,01.	100.
30.	3,00.	3,30.	109.
35.	3,24.	3,56.	118.
40.	3 46.	3,81.	126.
45.	3,67.	4,04.	133.
50.	3,87.	4,26.	141.
55.	4,06.	4,47.	148.
60.	4,24.	4,66.	154.
65.	4,42.	4,86.	161.
70.	4,58.	5,04.	166.
75.	4,74.	5,21.	172.
80.	4,90.	5,39.	178.
85.	5,05.	5,56.	183.
90.	5,20.	5,72.	189.
95.	5,34.	5,87.	194.
100.	5,48.	6,03.	199.

K. To find in what Proportion the Planets are enlightned by the SUN.

The Famous M. *Azout*, uſed to enlighten an Object in what
pportion he pleaſed, by applying a great Object-Glaſs by
n, call'd a *Planetary* one; becauſe that by it he ſhew'd the Dif-
ence of Light, which all the Planets receive from the ☉, by
king uſe of ſeveral Apertures, Proportionate to their Di-
nces from the ☉, provided that for every 9 Foot Draught,
thereabout one Inch of Aperture be given for the Earth.
Whence he obſerv'd, that the Light which *Mercury* receives is
enough from being able to burn Bodies, and yet the ſame
ht is great enough in ♄ to ſee clear there; ſeeing that it
ears greater in ♄, than it doth upon our Earth, when it
vercaſt with Clouds; which would ſcarce be believed, if by
ans of this Glaſs it did not ſenſibly appear ſo.

. To make the Picture of any Thing appear in a Light Room.

ppoſite to the Place or Wall, where the Apparition is to
let a Hole be made of about a Foot in Diameter, or bigger,
here be an high Window, that hath a Caſement in it, 'twill
ſo much the better.
Without this Hole or Caſement open'd, at a convenient Di-
ce, (that it may not be perceived by the Company in the
om) place the Picture or Object to be repreſented, in an in-
ted Order, if poſſible, and by means of Looking-Glaſſes placed
ind, if the Picture be tranſparent, reflect the Rays of the
ſo as that they may paſs thro' it, towards the Place where
s to be repreſented, and to the End, that no Rays may paſs
des it, let the Picture be encompaſs'd on every Side, with
oard or Cloth.
f the Object be a Statue, or ſome living Creature; then it
t be very much enlightned by caſting the Sun-beams on it,
Refraction, *Reflexion*, or both.
etween this Object, and the Place where it is to be repre-
ted, there is to be placed a broad Convex-Glaſs ground of
a Convexity, as that it may repreſent the Object diſtinct
the ſaid Place, which any one that hath Inſight in *Optics*,
eaſily direct.

The

The nearer it is placed to the Object, the more is the O magnified on the Wall. and the further off, the leſs, which verſity is effected by Glaſſes of ſeveral Spheres.

If the Object cannot be inverted (as 'tis difficult to do Living Animals, Candles, *&c.*) then there muſt be two large G of convenient Spheres, and they placed at their appropri Diſtances (which are eaſily found by Tryals) ſo as to make Repreſentation erect. as the Object.

Theſe Objects *Reflecting* and *Refracting* Glaſſes, and the w Apparatus, as alſo the Perſons employ'd to Order, Change, make Uſe of them muſt be placed without the ſaid high W dow or Hole; ſo that they may not be perceived by the S ctators in the Room, and the whole Operation will be e perform'd.

Whatſoever may be done by means of the Sun-beams the Day-Time, the ſame may be done with much more Eaſ the Night, by the help of Torches, about the Lamps, or o bright Lights placed about the, Objects according to the ſeve Sorts of them.

XI. *Concerning* Teleſcopes, *where the Eye-Glaſs Concave.*

2. When the Eye-Glaſs is concave, the Effect is founded the ſame Principles, as in the Convex. The Diſtinctneſs of Appearance is procured in the ſame Manner; But here the Glaſs C D (in Fig. 2.) is placed between the Image E F, a the Object Glaſs A B: By this means the Rays. which co from the Right Hand Side of the Object, and proceed tow E the Left Side of the Image, being intercepted by the E Glaſs, are carried to the Left Side of the Eye; and the R which come from the Left Side of the Object, go to the Ri Side of the Eye; ſo that the Impreſſion in the Eye being verted, the Object appears in the ſame Situation. as when vie by the naked Eye. The Eye muſt here be placed cloſe to Glaſs. The Degree of magnifying, in this Inſtrument, is t to be found: Let the Rays, which paſs through the G A B at H. after the Refraction of the Eye-Glaſs C D diver as if they came from the Point G; then the Rays, which co from the Extremities of the Object. enter the Eye under t Angle at G, ſo that here alſo the Object will be magnifyed the Proportion of the Diſtance between the Glaſſes, to the D ſtance of G from the Eye-Glaſs.

The Space, that can be taken in at one View in the Teleſco depends on the Breadth of the Pupil of the Eye; for as t Rays. which go from the Points E F of the Image, are for thi

g distant from each other, when they come out of the Glass , if they are wider asunder than the Pupil, it is evident they cannot both enter the Eye at once. In the other escope the Eye is placed in the Point G, where the Rays come from the Points E or F cross each other, and there- must enter the Eye together. On this Account the Tele- e with Convex Glasses takes in a larger View than those Concave; but in these also the Extent of the View is li- ed, because the Eye-Glass does not, by the Refraction to- ds its Edges, form so distinct a Representation of the Ob- as near the Middle.

ence an Astronomical Telescope is easily converted into nd Telescope, by using three Eye-Glasses is for one; and the l Telescope, on the contrary, into an Astronomical one, taking away two Eye-Glasses, the Faculty of magnifying aining the same: Since the Distance of the Eye-Glass is small, the Length of the Telescope is much the same as if only used one.

From the Construction it is evident that the Length he Telescope is had, by adding five times the Semidia- er of the Eye-Glasses to the Diameters of the Object-Glass, Plane Convex, or its Diameter if a Convex on both s.

igens first observed, both in the Astronomical and Land scope, that it contributes considerably to the Perfection he Instrument, to have a Ring of Wood or Metal, with an rture, a little less than the Breadth of the Eye-Glass, fixed he Plane where the Image is found to radicate upon the next the Eye; by means hereof the Colors which are apt isturb the Clearness and Distinctness of the Object are pre- ed, and the whole Compass taken in at a View perfectly de- .

r *Isaac Newton*, in his admirable Treatise of Optics, Page 59. onstrates, That the Perfection of Telescopes is impeded by different Refrangibility of the Rays of Light, and not, as been vulgarly supposed, by the spherical Figures of Glas- and consequently they cannot be perfected by Glasses of figures of the Conic Section, *i. e.* by Parabolic, Hyperbo- lasses, *&c.* for having shewed the Ratio between the less greater Refractions of the different Rays to be very nearly 7 to 28. he saith, Those that are skill'd in Optics will ea- understand that the least circular Space, into which the t-Glasses of Telescopes can collect all Sorts of parallel , is about the 27½ Part of half the Aperture of the Glass, he 55 Part of the whole Aperture; and that the Focus of most refrangible Rays is nearer to the Object-Glass than the

the Focus of the leſs refrangible ones, by about 27½ P of the Diſtance between the Object-Glaſs, and the Focus of mean refrangible ones.

And if Rays of all Sorts flowing from any one lucid P in the Axis of any Convex Lens, be made by the Refra of the Lens to converge to Points not too remote from Lens, the Focus of the moſt refrangible Rays ſhall be n to the Lens than the Focus of the leaſt refrangible Rays a Diſtance which is to the 27½ Part of the Diſtance of th cus of the mean refrangible Rays from the Lens, as the ſtance between that Focus and the lucid Point from wh the Rays flow, is to the Diſtance between the lucid Point the Lens very nearly.

After this he ſhews, by Experiments made with very Accuracy, that the Rays of Light, which differ in Refra lity, do not all converge to the ſame Focus; but if they from a lucid Point, as from the Lens on the one Side, as Foci are on the other, the Focus of the moſt refrangible ſhall be nearer to the Lens than that of the leaſt refra by above the 14th Part of the whole Diſtance: And if flow from a lucid Point ſo very remote from the Glaſs, before their Incidence, they may be accounted parallel, th cus of the moſt refrangible Rays ſhall be nearer to the than the Focus of the leaſt refrangible, by the 27th or 28th of their whole Diſtance from it: And the Diameter of th cle in the Middle Space between theſe two Foci, which illuminate when they fall there on any Plane perpendi to the Axis, (which Circle is the leaſt into which the be gather'd) is about the 55th Part of the Diameter of t perture of the Glaſs; ſo that 'tis a Wonder the Teleſcop repreſent Objects ſo diſtinctly. But were all the Rays of equally refrangible, the Error ariſing only from the Sp city of Figures of Glaſſes, would be many hundred times And by Calculation, *Page* 70. he proves, That the Error a from the Spherical Figure of Glaſſes, to that ariſing from different Refrangibility of the Rays, is as 1 to 8151, and ſequently is ſo little, as deſerves not to be conſider'd.

There is another Argument (ſaith our excellent Au *p.* 73.) which proves, that the different Refrangibility o Rays is the true Cauſe of the Imperfection of Teleſcopes: the Errors of the Rays ariſing from the Spherical Figures o Object-Glaſſes, are as the Cubes of the Apertures of ſuch ject-Glaſſes; and thence to make Teleſcopes, of various Len magnify with equal Diſtinctneſs, the Apertures of the O Glaſſes, and the Charges, or magnifying Powers, ought to the Cubes of the Square Roots of their Lengths, which

ot anſwer to Experience: But the Errors of the Rays ariſing om the different Refrangibility, are as the Apertures of the bject-Glaſſes; and thence to make Teleſcopes of various Lengths agnify with equal Diſtinctneſs, their Apertures and Charges ght to be as the Square Root of their Lengths; and this anvers to Experience, as is well known: For Inſtance; a Teſcope of 64 Feet in Length, with an Aperture of $2\frac{4}{5}$ Inches, agnifies about 120 times with as much Diſtinctneſs as one of Foot in Length, with $\frac{1}{2}$ of an Inch Aperture, magnifies 15 mes.

By Reaſon of this different Refrangibility, he concludes: hat there can ſcarce be any other Means of improving Teſcopes by Refractions alone, beſides that of increaſing their ngths; for which End the late Contrivance of *Hugenius* ſeems ll accommodated, (ſee *Philoſophical Tranſactions*, N° 161.) for in Aerial Teleſcope, the Glaſſes are readily manageable, and Object-Glaſs being upon a ſtrong upright Pole, becomes re ſteady.

II. *Of the Conſtruction of a* Reflecting TELESCOPE.

The Catoptric or Reflecting Teleſcope, is a Teleſcope which ead of Lens's conſiſts chiefly of Mirrors, and exhibits reote Objects by Reflection, as the other Teleſcope before ſcrib'd does by Refraction.

The great Sir *Iſaac Newton*, conſidering the different Refranbility, which in his new Doctrine of Light and Colors he made appear the Light to conſiſt of.

In Effect, as he found the Ratio between the greateſt and ſt Refractions of the different Rays, to be nearly as 28 is to it eaſily followed, that the Rays could never be all refrac parallel from any Lens, but would ſome of them divarie, ſome more, ſome leſs, beſides that the Foci would be dirbed; the Focus of the more refrangible Rays being nearer Lens than thoſe of the leaſt refrangible Rays, by a Diſtance ich is the 27th Part of the Diſtance between the Objectaſs and the Focus of the leaſt refrangible ones.

Hence he concludes, that Refraction was too unequal a Prinle, and that Len's of whatever Figure, whether ſpherical paolical, or any other of the Conic Sections; and how truſoever ground, will never ſuffice for the Perfection of Teſcopes.

Upon this he had recourſe to another more equitable Prinple, *viz.* Reflection, and made a Teleſcope, conſiſting of a

Metalline Speculum, the firſt Hint whereof he owns he to
from Dr. *Gregory*'s Optics.

The Conſtruction of Sir *Iſaac Newton*'s reflecting Teleſcope
as follows. The Object-Metal A, Plate 8. Fig. 3. is placed
one End of the Octangular Tube B B at a a; the Tube is abo
Six Feet long, and a little wider than what is ſufficient to
ceive the Metal, dyed Black on the inſide, The Radius of
Sphere, on which the Concave Metalline Speculum muſt
ground fit for a Tube of ſuch a Length, will be about Te
Feet, and conſequently its Focal Length will be about 62 Inch
The Metalline Speculum is ſolder'd on the Back to another
Braſs, in the Back of which there is a Female Screw to rece
a Handle, whenever the Metal is to be moved, in order to
void ſullying its poliſh'd Surface by handling. As far with
the Focus of the Concave Speculum as is the Semidiameter
the Tube, there is to be placed an Oval Plane, compoſed o
Plate of the ſame Metal with the great Speculum, ſolder'd
the Back to another of Braſs. Its Breadth is ſomething l
than half an Inch, and is in Proportion to its Length as o
is to the Square Root of two. This plane Speculum is to
diſpoſed ſo, as to reflect the Rays to E, which Point will
the Focus of the Concave Speculum; and if a Sheet of Pa
were held to the Point E, the Image of the Object would
painted on the Paper by Reflection. There are belongi
to the Inſtrument three Boxes with Convex Eye-Glaſſes
be ſcrewed on at the Focus E, that by the Help of thoſe Gl
ſes, the Eye may receive the Rays parallel, which proceed fr
the Image of the Object at E. When the firſt or ſhalloweſt
the Eye-Glaſſes is made uſe of, it magnifies about 180 times
Diameter, with the Second about 200, and with the Third
bout 230 times: Each of thoſe Glaſſes has placed in that Foc
neareſt the Oval, a Circle to determine the Part of the Obj
ſeen at one View; and in the other Focus, towards the E
a Braſs Plate, with a little Hole in the Middle, to let no Li
paſs from the Eye to the Inſide of the Tube, but what co
from the Oval. Beſides theſe three Convex, there are two C
cave Eye-Glaſſes, with which it magnifies about 200 and
times, and alſo a Sett of three Convex Eye-Glaſſes, which t
it into a Day-Teleſcope, magnifying about 125 times. T
Aperture is limited by a Circle of Card or Paſtboard, pla
before the Object-Metal in the Tube. To vary the Apert
there are three of thoſe Circles, and the Apertures allowed
them are Five Inches and an Half, Five Inches, and Four
an Half, tho' for ſome Objects the whole Metal may be
open.

On the Top of the Tube is fix'd, on two ſmall Pedeſtals, a ommon Dioptric Teleſcope about 18 Inches long, its *Axis* pa- llel to that of the Tube, and having two Hairs placed in the ommon *Focus* of its Object, and Eye Glaſſes croſſing one ano- her in its Axis. By this Dioptric Teleſcope, the Object may e brought to be oppoſite to the Tube of the reflecting Tele- cope, much ſooner than to the reflecting Teleſcope alone, nd is repreſented in the Figure at M N.

The open Air has commonly an undulating Motion in its arts, eſpecially in the Day-time, which occaſions the Rays f Light to deflect a little from the ſtrait Lines in which they ught to move, in order to render the *Species* perfectly diſtinct: he Effect of this, though inſenſible to the naked Eye, or even hrough a ſmall Teleſcope, becomes conſiderable when the Ob- ct is very much magnified.

Dr. *Gregory*'s Reflecting Teleſcope (who was certainly the firſt hat gave the Conſtruction of thoſe Teleſcopes, tho' not the rſt that put them in Practice) is very much different from Sir *ſaac Newton*'s Teleſcope: The Conſtruction of Dr. *Gregory*'s is hus; Let A B C D, Plate 8. Fig. 4. be a Tube, open at D; in the End B C there is to be fitted a Concave Specu- m, m n, in which there muſt be a Hole x x agreeing to a ole y y of the Tube A B C D; within the Focus of the Con- ve Speculum, as at G, there is to be placed a plane Convex peculum as c c, which receiving the Image of the Object from he Concave Speculum, reflects the Rays back upon the Con- ve Speculum, diverging, a Quantity of thoſe Rays paſſes ro' the Hole x x, where they are received by the Tube l o c n, in which there are Eye-Glaſſes of the ſame Nature ith common Refracting Teleſcopes, which Tube M o c n, be- ng ſcrew'd to the Tube at y y, the Obſerver will receive a iſtinct Image of the Object, and erect: Thus tho' the Princi- les of Sir *Iſaac*'s and Dr. *Gregory*'s Teleſcopes be the ſame, yet heir Conſtruction are different, Sir *Iſaac*'s Teleſcopes having he Eye-Glaſſes placed upon the Side of the Tube, as at e, and n Dr. *Gregory*'s Teleſcopes they are placed in the End, as at y. where they look directly as in Refracting Teleſcopes. oth Sorts of theſe Reflecting Teleſcopes are now made to ve- y great Perfection, by *Edward Scarlet*, Optician to his Ma- eſty, by St. *Ann*'s Church, *Soho*; he has lately made one of Dr. *regory*'s Teleſcopes of about 9 Inches in Length, by which he Satellites of *Jupiter* are very diſtinctly obſerved: Alſo, here is a late Contrivance, by which the Azimuth and Alti- ude of any Cœleſtial Phænomenon, may be obſerved at the ame Time that the Object is obſerved by thoſe reflecting Te- eſcopes: But this Contrivance, as alſo the Movements, which

carry the Teleſcope either vertically or horizontally, are immediately underſtood when ſeen.

XIII. *Of the Uſes of* TELESCOPES.

By the Help of Teleſcopes diſtant Objects are more certainly and exactly obſerved than they can be by our ſimple View; for by the Meaſure of Angles we find the apparent Diameters of diſtant Bodies, for the apparent Diameters of Bodies grow bigger the nearer we come to them, and that they are increaſed almoſt in the ſame Proportion that the Eye approaches them; (for Example; If any Man were ten times nearer to the Moon than we are, and did there obſerve her, he would ſee the Moon ten times bigger in her Diameter, and clearer than we do; (in Diameter, I ſay, for the Surface would appear 100 times larger than it does to us). If here on our Earth we ſhould take a Teleſcope, which only encreaſes the Diameter ten times, and look to the Moon with it, the Moon will have the ſame Appearance ſeen with ſuch a Teleſcope, as would appear to a Spectator ten times nearer the Moon than we are; but if we ſhould uſe Teleſcopes (and ſuch there are) which magnify the Diameters of Objects 100 or 200 times, they will ſhew the Moon in the ſame Manner, Figure, and Bigneſs, as it would appear in, at a Diſtance 100 or 200 times leſs than ours is from the Moon. Hence we can perceive, with our Eyes, what Face, and how large the Moon would ſhew itſelf at the Diſtance of three Diameters of the Earth: As likewiſe, we can diſcern how the Moon would appear if we approach'd much nearer, and view her only at the Diſtance of 1900 Miles, for from thence we ſhould be able to diſcover, in the Moon, vaſt Ridges of Mountains, deep Caverns, many Vales, and large open Fields. By the Means of Teleſcopes we ſtill aſcend higher in the Heavens, and we can approach the Planets and Comets and fixed Stars, ſo near, that of ſuch immenſe Diſtances there remains only the Hundredth or Two Hundredth Part to have the whole Journey finiſhed; for, as is before obſerv'd, a Teleſcope, that magnifies One Hundred Times, makes any Object appear to us, when view'd by ſuch Teleſcope, as if the Diſtance between the Obſerver and that Object were divided into One Hundred equal Parts, and if the Obſerver were removed Ninety Nine of thoſe Parts nearer to the Object the Obſerver, with the naked Eye, would then ſee the Object in the ſame Bigneſs in Diameter and Surface, and other Appearances, as the ſame Obſerver on our Earth obſerves the ſame

Object

bject with a Teleſcope that magnifies One Hundred times; and Teleſcopes are of vaſt Uſe in obſerving the apparent Diame-rs of the Cœleſtial Bodies, ſo likewiſe we thereby are able to dge of the Proportion of their Diſtances from us, and the roportion their true Diameters bear to one another; for if eir Diſtances be equal, their true Diameters will be as their pparent, and if their apparent Diameters are equal, their true iameters will be proportional to their Diſtances: Hence, if the pparent Diameters of the Sun and Moon be equal, let the n be One Hundred times further from us than the Moon, the n muſt needs be One Hundred times in Diameter bigger than e Moon.

If we know the apparent Diameter of any Body, we can om thence exactly know by the help of Trigonometrical Ta-es what Proportion the Diſtance of that Body bears to its ue Diameter; for ſuppoſe any Object to be ſeen by the Eye der an Angle of one Degree; the Diſtance of that Object ll be to its Diameter, as the Radius of a Circle is to the Tan-nt of one Degree. The Sun appearing under an Angle of out half a Degree, or 30 Minutes; this Diſtance will be to real Diameter as 10000 to 87, the Tangent of half a Degree. nce we are certain, that the Sun's Diſtance from us is near-equal to 115 of his own Diameters; and if an Eye were ced on the Sun to obſerve the Angle under which the ameter of the Earth appear'd from thence: we then ſhould able to tell exactly the Diſtance of the Sun from us in Dia-ters of the Earth or Miles.

In order to determine the apparent Diameters of the Pla-es; as alſo to meaſure other ſmall Diſtances in the Heavens curately; there have been ſeveral ſorts of Micrometers apply'd the Eocus's of Teleſcopes: the Conſtruction of the moſt ple of thoſe Micrometers is as follows: In the Focus of a leſcope fit a Braſs or Iron Ring A B with Female Screws dia-trically oppoſite to each other; into theſe Female Screws ert Male Screws A E and F B of ſuch Lengths as that they y be turn'd into the Tube ſo as to meet each other, and th this Inſtrument very ſmall Spaces in the Heavens may be curately meaſured; for when any two Objects view'd thro' Tube appear contiguous to the Screws, if the Teleſcope be n'd about to two other Points that do alſo exactly appear ntiguous to the Screws, they remaining in the ſame Poſiti-as before, if the Diſtance aſunder of thoſe two latter Points known or can be meaſured, the ſame will be the Diſtance a-nder of the firſt two Objects. To determine how many Se-nds anſwer to each Thread of thoſe Screws, obſerve two nts in the Heavens, whoſe Diſtance is accurately known, and

turn

turn the Screws till they appear contiguous with thoſe know
Objects; and obſerve the Number of Threads correſpondi
to that Interval; then by the Rule of Three it may eaſily
determin'd how much of that, or any other Interval agrees
every Thread of the Screw; thus, by ſaying, As the Numb
of the Threads of the Screws requir'd to meaſure the know
Diſtance, is to the known Diſtance in Seconds; ſo is one Thre
to a fourth Number, which fourth Number is the Number
Seconds anſwering to each Thread of every Screw. After t
ſame manner may a Table be made, by which the apparent D
ſtances of Objects, or the apparent Diameters of the Plan
may be found by Inſpection; having the Number of Thre
of the Screws that meaſure that Interval.

N. B. The Screws ſhould be as exactly made as poſſible.

A Complete ACCOUNT OF OUR SOLAR SYSTEM, CONTAINING the PLANETS, COMETS, AND FIXED STARS.

SECT. I.

THIS true Solar Syſtem was the moſt Antient of all firſt introduced into *Greece*, by the Great *Pythagoras*, and his Diſciples, who had learnt it from the Wiſemen of the *Eaſt*, to whom as to an Univerſity, they then all reſorted for Inſtruction. 'Tis true the other Apparent Syſtem, which ſuppoſes the Earth immoveable, and the Heavens to revolve about it, was received among the Vulgar, and Illiterate part of Mankind; yet the Philoſophers retain'd the true Syſtem; till *Ariſtotle*, and the Philoſophers that came after him, degenerating from their Predeceſſors, and not being acquainted with the Philoſophy, embraced the common Syſtem of the Vulgar: ſo that the Antient Syſtem was forgot, and not minded till the Time of *Nicolaus Copernicus*, who again brought it to Life, and retrieved

retrieved it from Oblivion, and eſtabliſhed it by Solid Arguments and Reaſons, whence this Syſtem is now call'd the Copernican Syſtem.

After the Invention of Teleſcopes, the Secundary Planets with many New, and unthought of Appearances were obſerved in the Heavens by the Aſtronomers ſince the laſt Century, which did wonderfully enlarge the Antient Syſtem, and confirm'd it with Invincible Demonſtrations, *viz.*

That the Earth could not be the Center of the Planetary Motions at reſt, becauſe of

The Retrogradations of the Planets. The Appearance of their unequal, and irregular Motions. The Phænomena of ♂, ♀ and ☿ eſpecially prove they revolve about the ☉. The Gravitation of ☉ and Earth. The Harmony of the Planets, Periods, Diſtances and Revolutions about their Axes. The Oblate Spheroidical Form of the Earth, which is 31 Miles higher at the Equator than the Poles. Alſo,

When two *fixed Stars* ſometimes aſunder, do appear at other Times to eclipſe each other: and above all the Annual Parallax of the *fixed Stars*. Alſo, If the Earth were the Center ♀, and ☿ muſt have all the Aſpects, whereas neither has ſo much as □ ✱: ♀ and ☿ paſs between the Earth and Sun, and appear Spots, which could not be, if the Earth was the Center of the Motion: Laſtly, the *Phaſes* of ♀, which the Teleſcopes diſcover to be like thoſe of our ☽ do invincibly confirm the ſame.

Before the Invention of this noble Inſtrument, when *Copernicus* firſt revived the antient *Pythagorean* Syſtem, and propos'd it to the Learned in Aſtronomy, to whom he maintained, that the Planets, among which, he reckon'd the Earth did move round the Sun, which was immoveable in the Center: It was objected to him, that if the Motions of the Planets were ſuch as he ſuppoſed them to be, that then ♀ ought to undergo the ſame Changes and Phaſes, as the ☽ does. *Copernicus* anſwer'd, *that perhaps the Aſtronomers in after Ages, would find that ♀ does not undergo all theſe Changes.* This Prophecy of *Copernicus* was firſt believ'd and fulfill'd by that great *Italian* Philoſopher *Galileus*, who directing his Teleſcope to ♀ obſerved her Appearances to emulate the ☽, as *Copernicus* had foretold, and theſe Obſervations did ſurprizingly confirm the Old Syſtem.

True Aſtronomy has all its Parts fitly joyn'd together in the moſt agreeable Harmony and Order, it leads us to the Knowledge of the Univerſe, and the wonderful Symmetry, Beauty and regular Diſpoſition of all the Bodies that compoſe it, to that Infinite Wiſdom, who made all things in Number, Weight and Meaſure, who *doth nothing in Vain, nor uſes many things, when few will perform*: There is nothing in Nature, that does more ſhew

piercing Force of human Underſtanding, the Sublimity of its culations, and deep reſearches, than true Aſtronomy: It rai- our Minds above our Senſes, and even in Contradiction them ſhews us the *true Syſtem of the World.* The Faculty of aſon, by which we have made theſe great Diſcoveries in the avens, muſt needs be derived from Heaven: ſince no Earth- principle can attain ſo great a Perfection, and ſince the Ori- ation of our Minds is from Heaven, it may be expected that y will endeavour to return thither, and Heaven will become r final Habitation.

Twas neceſſary for the Advancement of Aſtronomy to diſtin- iſh the Stars into Aſteriſms or Conſtellations by Figures and ages, which are of great Antiquity, and ſeem to be as Old Aſtronomy or Philoſophy it ſelf: for in the moſt antient ok of *Job*, *Orion*, *Arcturus*, and the *Pleiades* are mention'd, and meet with the Names of many in the Writings of the firſt ets, *Homer* and *Heſiod*, by the Help of which Conſtellations, the tient Aſtronomers have been able to diſtinguiſh, and mark out e Stars of the Firmament, and with great Care and Induſtry ey have digeſted them into Catalogues, which they have de- er'd down to Poſterity; theſe Catalogues have been much creaſed, and corrected by our Modern Aſtronomers, for now ey not only comprehend the Stars viſible by the naked Eye, t alſo many that are not to be obſerv'd or ſeen without a eleſcope.

Hipparchus the *Rhodian*, about 120 Years before the Birth of HRIST, was the Firſt among the *Greeks*, who reduced the ars into a Catalogue, daring, according to *Pliny*, to undertake thing, which ſeem'd to ſurpaſs the Power of Mortals, that is Number the Stars for Poſterity, and to reduce them to ule, *&c.*

Hipparchus, from his own proper Obſervations, and thoſe of e antient Aſtronomers before him inſerted into his Catalogue 22 Stars, and annexed to each of them their proper Longi- de and Latitude; which they had at that Time.

Ptolomy enlarg'd *Hipparchus*'s Catalogue only with four Stars umbring 1026.

Then *Ulug Beighi* the Grandſon of the great *Tamerlane* ob- erv'd again the Stars, and reduced 1017 of them into a Cata- ogue.

In the Sixteenth Century, and ſince, Aſtronomy was courted by any Admirers and Suiters, among whom we may chiefly reckon egiomontanus and *Copernicus*. But the noble *Daniſh* Aſtronomer, ycho Brahe, in adorning and perfecting this Science did far urpaſs the Labours of all that went before him; who procured ery large, and exquiſitely well contrived Inſtruments, for ob-

ſerving the Heavens, and particularly he determin'd the pla
of 777 fixed Stars, and reduced them into a Catalogue, th
places being all calculated from his own proper Obſervatio
Kepler, encreaſed that Number, to 1163, from *Ptolomy*, and
ther Authors.

Cotemporary with *Tycho*, was *William Prince of Heſs*, who li
wiſe obſerv'd the Stars, and with the Aſſiſtance of *Rothm*
and *Byrgius* two Mathematicians, by 30 Years contin
Labour computed the places of 400 Stars, all founded on th
own Obſervations, and inſerted them in a Catalogue.

The Jeſuit *Ricciolus* enriched the Catalogue of *Kepler*, wi
305 Stars, by which means their Number was encreaſed to 1
but not above 100 were of his own Obſervation, the re
took from *Tycho*, *Kepler*, and others.

Bartſchius, in his Book of the 4 Foot Globe, boaſts that
himſelf had painted on his Globe 1762 Stars; but does n
tell us by whom, or in what Year they were obſerved.

The *Southern* Stars, which are not ſeen in our Climate, we
firſt accurately obſerv'd by Doctor *Edmund Halley*, now Ro
Profeſſor of Aſtronomy, in the Iſland of St. *Helena*, and pu
liſh'd a Catalogue of 373 of them, whoſe places he adapted to
End of the Year 1677.

The illuſtrious *John Hevelius* of *Dantzick*, with indefatiga
Induſtry computed the places of 1553 Stars from his own pr
per Obſervations, and ſo he compoſed a New Catalogue, wh
contain'd 1888, *viz.* 950 known to the Antients, 603 New on
which no one before had ever rightly obſerved, and to the
he joyn'd 335 *Southern* Stars taken out of Doctor *Halley*'s Ca
logue, which never appear in the Horizon of *Dantzick*.

But the Largeſt, and moſt Complete Catalogue of the Sta
we have from the Labours of that excellent Obſerver, *J*
Flamſteed, late Royal Profeſſor of Aſtronomy: whoſe Numb
reach to 3000. rectified to the Year 1726. as *Hevelius* doubl
by his Obſervations, the Number of Stars obſerv'd by *Tych*
our *Britiſh* Aſtronomer has as far out done *Hevelius*. We are
much indebted to this Aſtronomer for the Increaſe of t
Knowledge we have of the Celeſtial Bodies, that there is no
the leaſt Star in the Heavens to be ſeen, whoſe Place and S
tuation is not better known, than the Poſition of many C
ties, thro' which Travellers do daily paſs. Nor is it any Wo
der, that the Aſtronomers ſhould take ſo much Pains, and
obſtinately watch the *fixed Stars*, to determine their places: f
without the exact ſetling of their Poſitions and Places th
could never have found out the Ways of the Planets, n
have deſcribed their Orbits; for 'tis upon the Obſervation

THE SOLAR SYSTEM

according to their mean

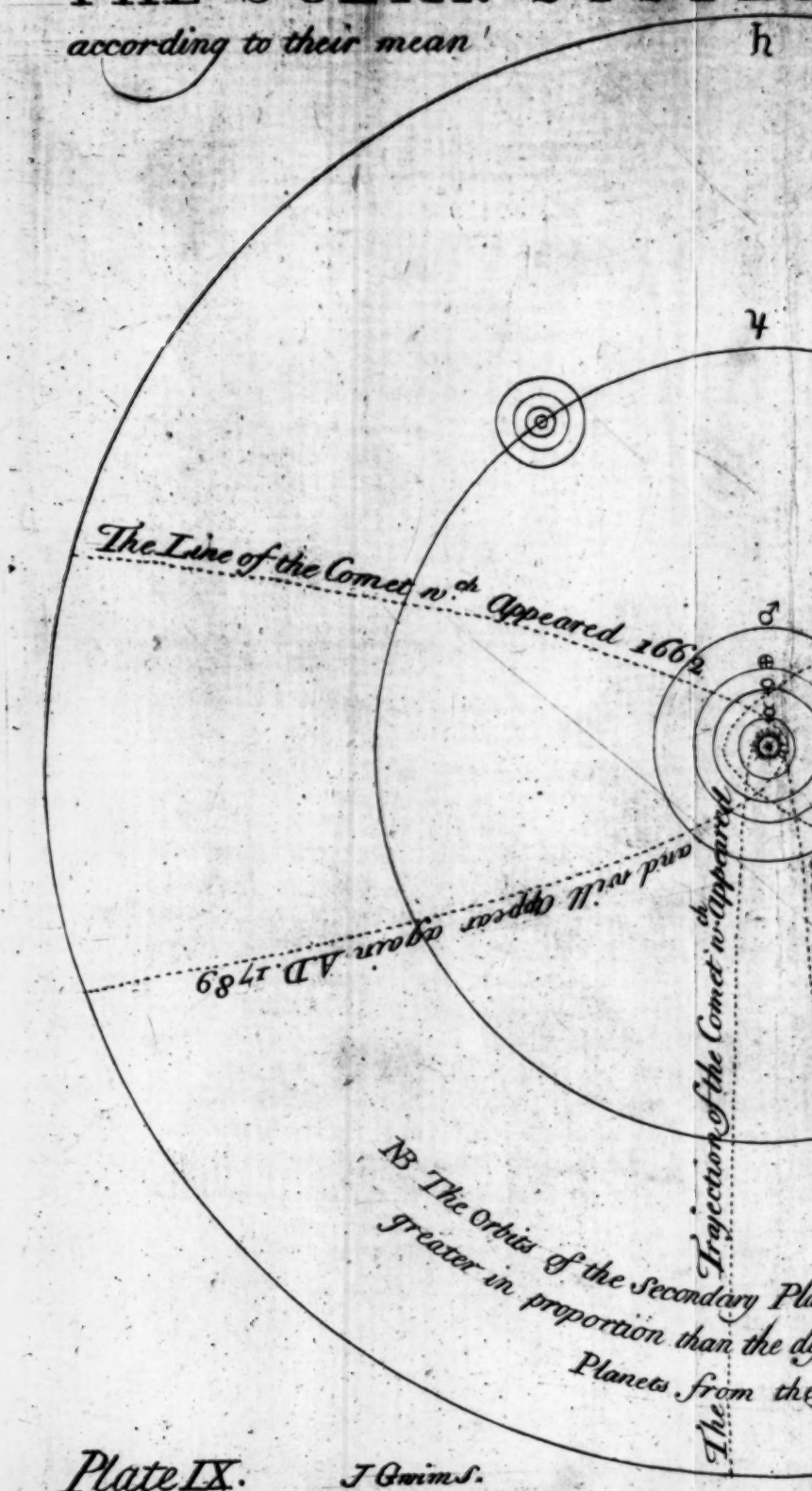
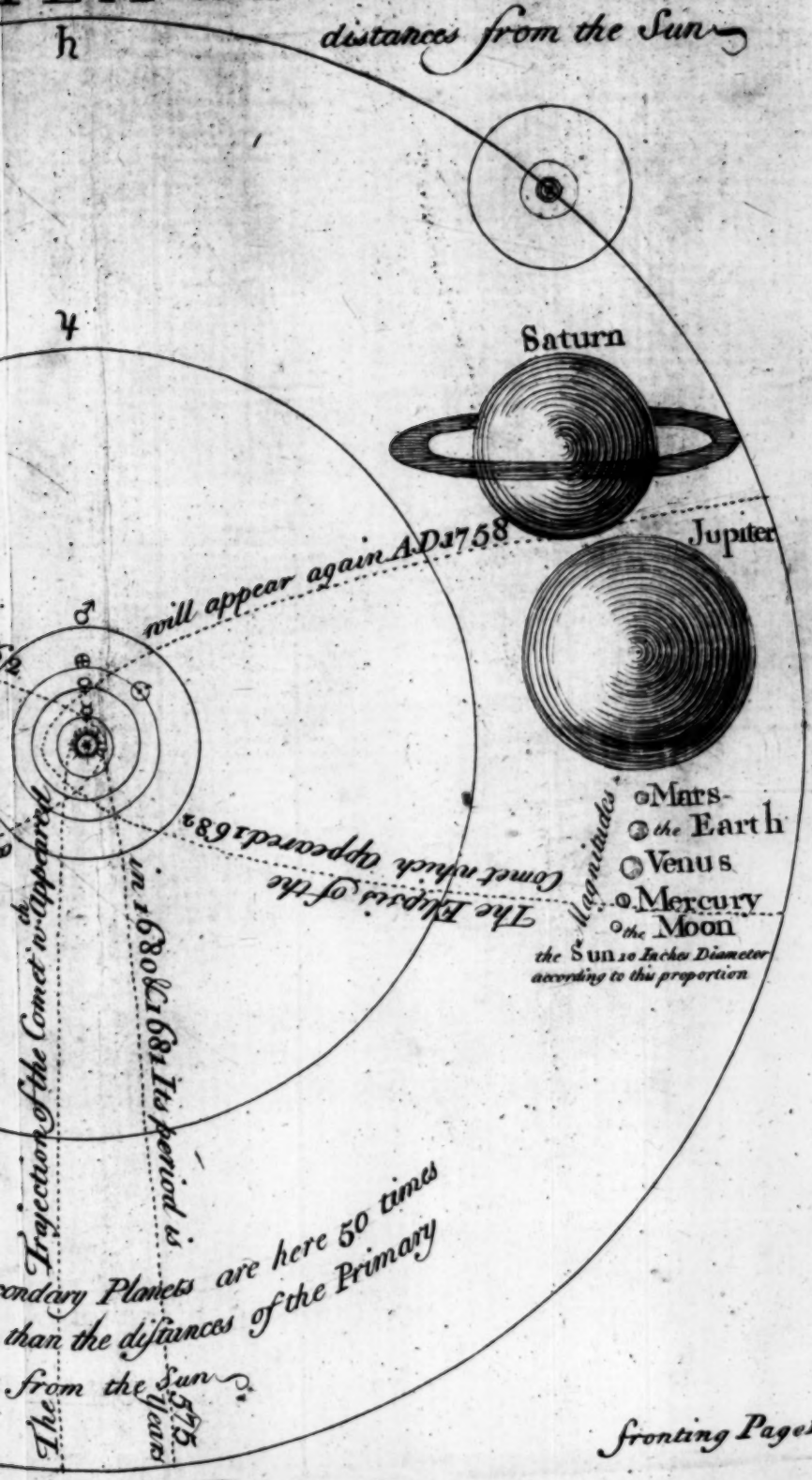


Plate IX. J Grimsʃ.

TEM Or the Orbits of the Planets



fronting Page 16

Stars, that the whole Science of Astronomy is erected, them it is sustain'd.

e not in the following Sheets, which are principally l to instruct, divert, and improve young Gentlemen, d them with the physical Causes of the Celestial Moti- ich to understand clearly, require an Insight into deep ry, lest it should at first confound, and make the e too difficult: therefore,

ught it more advantageous to explain the Motions, and Account of the Phænomena, that arise from these Mo- which when once understood, there will be an easy Ad- into the Knowledge of their Physical Causes, which n with Ease and Advantage be learnt from the Excellent of Doctor *Gregory*, and the incomparable Sir *Isaac Newton*.

e I enter upon the Planetary, and Cometary System, the Noblest part of Astronomy, give me leave to ad- Courteous Reader, that I shall confine my self to the Account, and meddle with nothing of *Eccentrics*, *Epicycles* *ibrations*, *Solid Orbs*, and the Hypotheses of *Ptolomy*, *Tycho*, why should I tire and perplex with Shadows and Sy- lly exploded, when the Truth is manifest, whereby the Order, Position and Places of the Planets may be nd understood far better, and more easily, according ue, than according to these *Fictitious* Systems.

I may not set forth the Contrivances of Mortals; but to be admired and adored Wisdom of the Great and Glo- eator, of whom the Royal Psalmist under a Divine In- thus breaks forth. *The Heavens declare the Glory of God, and nent sheweth his handy Work*; and again *the Heavens declare his ess, and all the People have seen his Glory.*

he Order and Periods of the Primary Planets ving about the SUN; *and of the Secondary Pla- round their respective Primaries.*

un is placed in the midst of an immense Space, where- Opake Spherical Bodies revolve about him Center. These wandring Globes are called *Planets*. ets, who at different Distances, and in dif- eriods, perform their Revolutions from *West* to *East*, in wing Order.

Mercury is nearest to the Sun of all the Planets, and s its Course in about three Months. ♃ ♀ *Venus* in a-

racters placed before the Names of the Planets, are for Brevity's sake made use of by Astronomers, instead of the Words at length, as ♀ *&c.*

bout ſeven Months and a Half. 3. ♁ *The Earth* in a Year. ♂ *Mars* in about two Years. 5. ♃ *Jupiter* in twelve. And lastly, ♄ *Saturn*, whoſe * *Orbit* includes all the reſt, ſpends almost 30 Years in one Revolution round the Sun. The Diſtances of the Planets from the Sun are nearly in the ſame Proportion as they are repreſented in *Plate 9. viz.* Suppoſing the Diſtance of the Earth from the Sun to be divided into 10 equal parts, that of *Mercury* will be about 4 of theſe parts; of *Venus* 7; of *Mars* 15; of *Jupiter* 52; and that of *Saturn* 95.

The Orbits of the Planets are not all in the ſame Plane, but variouſly inclined to one another; ſo that ſuppoſing one of them to coincide with the above Scheme, the others will have one half above, and the other half below it; interſecting one another in a Line paſſing through the Sun. The Plane of the Earth's Orbit, is called the *Ecliptic.* and this the Aſtronomers make the Standard, to which the Planes of the other Orbits are judged to incline. The right Line paſſing thro' the Sun, and the common Interſection of the Plane of the Orbit of any Planet and the Ecliptic, is called the *Line of the Nodes* of the Planet; and the Points themſelves, wherein the Orbit cuts the Ecliptic, are called the *Nodes.*

Ecliptic.

Nodes.

The Inclinations of the Orbits of the Planets to the Plane of the Ecliptic, are as follows, *viz.* The Orbit of *Mercury* makes an Angle with it of almoſt 7 degrees; that of *Venus* ſomething above 3½ degrees; of *Mars*, a little leſs than 2 degrees; of *Jupiter*, 1⅓ degrees, and of *Saturn*, about 2½ degrees. The Orbits of the Planets are not Circles, but Ellipſes or Ovals. What an Ellipſis is, may be eaſily underſtood from the following Deſcription. Imagine two ſmall Pegs fixed upright on a Plane, and ſuppoſe them tyed with the Ends of a Thread ſomewhat longer than their Diſtance from one another; now if a Pin be placed in the double of the Thread, and turned quite round, (always ſtretching the Thread with the ſame Force) the Curve deſcribed by this Motion is an *Ellipſis.* The two Points where the Pegs ſtood, (about which the Thread was turned) are called the *Foci* of that Ellipſis; and if without changing the Length of the Thread, we alter the Poſition of the Pegs, we ſhall then have an Ellipſis of a different Kind from the former; and the nearer the *Focus*'s are together, the nearer will the Curve deſcribed be to a Circle; until at laſt the two *Focus*'s coincide, and then the Pin in the doubling of the

* By the Orbit of a Planet, is commonly underſtood the Tract or Ring deſcribed by its Center round the Sun; but by the Plane of the Orbit is meant a flat Surface extended every way thro' the Orbit infinitely.

Three

hread will deſcribe a perfect Circle. The Orbits of all the anets, have the Sun in one of their *Focus*'s; and lf the Diſtance between the two *Focus*'s is called the *Eccentricity.* centricity of the Orbits. This Eccentricity is dif- rent in all the Planets; but in moſt of them it is ſo ſmall, at in little Schemes or Inſtruments, made to repreſent the anetary Orbits, it need not be conſidered.

The Six Planets above-mention'd, are called *Pri-* ries, or *Primary Planets*; but beſides theſe, there are *Primary Planets.* n other leſſer Planets, which are called *Secondaries,* ons or *Satellits*. Theſe Moons always accompany *Secondary Planets.* eir reſpective Primaries, and perform their Revo- tions round them; whilſt both together are alſo rried round the Sun. Of the Six Primary Planets, there are t three, as far as Obſervations can aſſure us, that have theſe tendants, *viz.* the *Earth*, *Jupiter*, and *Saturn*.

The Earth is attended by the *Moon*, who perſorms her Re- lution in about 27⅓ days, at the Diſtance of about 30 Dia- eters of the Earth from it; and once a Year is carried round e Sun along with the Earth.

Jupiter has four *Moons* or *Satellits*; the *firſt* or inner- Jupiter's *four Moons.* oſt performs its Revolution in about one Day and ⅛ Hours, at the Diſtance of 5⅔ Semidiameters of piter from his Center; the *ſecond* revolves about *Jupiter* in 3 ys and 13 Hours, at the Diſtance of 9 of his Semidiameters; e *third* in 7 Days and 4 Hours, at the Diſtance of 14⅓ Semi- meters; the *fourth* and *outermoſt*, performs its Courſe in the ace of 16 Days 17 Hours, and is diſtant from *Jupiter*'s Center, ⅓ of his Semidiameters.

Saturn has no leſs than five *Satellits*; the *firſt* or in- Saturn *has five Moons.* rmoſt revolves about him in 1 Day and 21 Hours the Diſtance of 4⅓ Semidiameters of ♄ from his enter; the *ſecond* completes its Period in 2¾ Days at the di- nce of 5⅔ of his Semidiameters; the *third*, in about 4½ Days the Diſtance of 8 Semidiameters; the *fourth* performs its Courſe about 16 Days, at the Diſtance of 18 Semidiameters; the h and outermoſt takes 79 ⅓ Days to finiſh his Courſe, and is Semidiameters of *Saturn*, Diſtant from his Center. The Sa- llits as well as the Primaries perform their Revolutions from ſt to *Eaſt*: the Planets or the Orbits of the Satellits of the me Planet are variouſly inclined to one another. and conſe- ently are variouſly inclined to the Plane of the Orbit of their imary.

Beſides theſe Attendants, *Saturn* is encompaſſed with Saturn's *Ring.* hin plane Ring that does no where touch his Bo- : the Diameter of this Ring is to the Diameter of *Saturn* as 9 to

9 to 4; and the void ſpace between the Ring and the Body of *Saturn*, is equal to the breadth of the Ring it ſelf; ſo that in ſome ſituations the Heavens may be ſeen between the Ring and his Body. This ſurpriſing Phænomenon of *Saturn's Ring* is a modern Diſcovery; neither were the Satellits of *Jupiter* and *Saturn* known to the Antients. The *Jovial* Planets were firſt diſcovered by the famous *Italian* Philoſopher *Galilæus*, by a Teleſcope, which he firſt invented; and the celebrated *Caſſini*, the *French* King's Aſtronomer, was the firſt that ſaw all the Satellits of *Saturn*; which by reaſon of their great Diſtances from the Sun, and the ſmallneſs of their own Bodies, cannot be ſeen by us. but by the help of very good Glaſſes.

Annual Motion. The Motion of the primary Planets round the Sun (as alſo of the Satellits round their reſpective Primaries) is called their *Annual Motion*; becauſe they have one Year or Alteration of Seaſons complete in one of theſe Revolutions. Beſides this Annual Motion, four of the Planets, *viz. Venus*, the *Earth*, *Mars*, and *Jupiter*, do volve about their own *Axes*, from *Weſt* to *Eaſt*; this is called their *Diurnal Motion*. For by this Rotation each point of their Surfaces, is carried ſucceſſively towards or from the Sun, who always illuminates one Hemiſphere which is next to him. the other remaining obſcure: and while any Place is in the Hemiſphere illuminated by the Sun it is *Day*; but when it is carried to the obſcure Hemiſphere it becomes *Night*, and ſo continues until by this Rotation the ſaid place is again enlightned by the Sun.

Diurnal Motion.

Diurnal Motion of the Earth, Venus, Mars, and Jupiter. The *Earth* performs its Revolution round its Axis in 23 Hours 56 Minutes; *Venus* in 23 Hours; *Mars* in 24 Hours and 40 Minutes; and *Jupiter* more round his own Axis in 9 Hours and 56 Minutes. The Sun alſo is found to turn round his Axis from *Weſt* to *Eaſt* in 27 Days: And the Moon, which is neareſt to us of all the Planets, revolves about her Axis in a Month, or in the ſame ſpace of Time that ſhe turns round the Earth; ſo that the Lunarians have but one Day throughout their Year.

Sun and Moon likewiſe turn round their Axes.

The Planets are Opake and Globular. I. The Planets are all opake Bodies, having no Light but what they borrow from the Sun: For that ſide of them which is next towards the Sun, has always been obſerved to be illuminated, in what poſition ſoever they be; but the oppoſite ſide, which the Solar Rays do not reach, remain dark and obſcure; whence it is evident that they have no Light but what proceeds from the Sun: for if they had, all parts of them would be lucid without any Darkneſs or ſhadow. The Planets are likewiſe proved to be Globular, becauſe let what part ſoever of them be turned

toward

wards the Sun, its Boundary, or the Line ſeparating that rt from the oppoſite, always appears to be Circular; which uld not happen if they were not Globular.

II. That the Earth is placed betwixt the Orbs of rs and *Venus*, and that ☿, ♀, ♂, ♃, and ♄, do turn round the Sun; is proved from Obſervati- s as follow: *The Planets turn round the Sun.*

. Whenever *Venus* is in Conjunction with the Sun, that is, en ſhe is in the ſame Direction from the Earth, or towards ſame part of the Heavens the Sun is in; ſhe either appears th a bright and round Face like a full Moon, or elſe diſap- rs; or if ſhe is viſible, ſhe appears horned like a new Moon; ich Phænomena could never happen, if ♀ did not turn round Sun, and was not betwixt him and the Earth: For ſince the Planets borrow their Light from the Sun, it is neceſſary t ♀'s lucid Face ſhould be towards the Sun; and when ſhe pears fully illuminated, ſhe ſhews the ſame Face to the Sun d Earth; and at that time ſhe muſt be above or beyond the n, for in no other Poſition could her illuminated Face be n from the Earth. Farther, when ſhe diſappears, or if viſible, pears horned; that Face of hers which is towards the Sun, ither wholly turned from the Earth, or only a ſmall part it can be ſeen by the Earth; and in this caſe ſhe ſt of neceſſity be betwixt us and the Sun. Let e the *Sun*, ♁ *Earth*, and ♀ *Venus*, having the ſame e preſented both towards the *Sun* and *Earth*: here s plain that the Sun is betwixt us and *Venus*, and therefore muſt either place *Venus* in an Orbit round the *Sun*, and like- e betwixt him and us, as in *Fig.* 1. or elſe we muſt make the to move round the Earth in an Orbit within that of *Venus*, n *Fig.* 2. Again, after *Venus* diſappears, or becomes horned, her ☌ ♂ with the ☉, ſhe then muſt be betwixt us and the , and muſt move either in an Orbit round the Sun, and wixt us and him, as in *Fig.* 1. or elſe round the Earth, and wixt us and the Sun, as in *Fig.* 2. But *Venus* cannot move metimes within the Sun's Orbit, and ſometimes without it, we muſt ſuppoſe if ſhe moves round the Earth; therefore s plain that her Motion is round the Sun. *Plate* 10. *Fig.* 1. 2.

eſides the foregoing, there is another Demonſtration that t turns round the Sun, in an Orbit that is within the Earth's; auſe ſhe is always obſerved to keep near the Sun, and in

☌ is a Mark commonly uſed for Conjunction; thus ☌ with the ☉ is to ead Conjunction with the Sun.

the

the ſame Quarter of the Heavens that he is in: for ſh
recedes from him more than about ⅓ of a whole Circ
therefore can never come in Oppoſition to him; whic
neceſſarily happen, did ſhe perform her Courſe round t
either in a longer or ſhorter time than a Year. And th
reaſon why *Venus* is never to be ſeen near Midnight, bu
either in the Morning or Evening, and at moſt not abo
or four Hours before Sun-riſing, or after Sun

Why Venus *is always either our Morning or Evening Star.*

From the time of ♀'s ſuperior Conjunction (
ſhe is above the Sun) ſhe is more Eaſterly
Sun, and therefore ſets later, and is ſeen a
ſetting, and then ſhe is commonly called
ing Star. But from the time of her inferi
junction till ſhe comes again to the ſuperior, ſhe then
more Weſterly than the Sun, and is only to be ſeen
Morning before Sun-riſing, and is then called the
Star.

After the ſame manner, we prove that *Mercury* turns ro
Sun, for he always keeps in the Sun's Neighbourhood.
ver recedes from him, ſo far as *Venus* does; and there
Orbit of ☿ muſt lie within that of ♀; and on the acc
his Nearneſs to the Sun, he can ſeldom be ſeen witho
leſcope.

The Orbit of Mars *includes the Earth's.*

Mars is obſerv'd to come in Oppoſition, a
wiſe to have all other Aſpects with the Sun
ways preſerves a round, full, and bright
cept when he is near his Quadrat Aſpect
he appears ſomewhat Gibbous, like the Moon three
Days before or after the Full: Therefore the Orbit of
include the Earth within it, and alſo the Sun; for if
betwixt the Sun and us, at the time of his inferior Co
on, he would either quite diſappear, or app
ned, as *Venus* and the Moon do in that
Let S be the *Sun*, T the *Earth*, and A, P *Mars*,

Fig. 1.

his Conjunction and Oppoſition to the Sun, and in
ſitions full; and B, C *Mars* at his Quadratures, when he
ſomewhat gibbous from the Earth at T: 'Tis plain her
the Orbit of *Mars* does include the Earth, otherwiſe h
not come in Oppoſition to the Sun; and that it
includes the Sun, elſe he could not appear full at h
junction.

Mars, when he is in Oppoſition to the Sun, looks al
ven times larger in Diameter, than when he is in Co
on with him; and therefore muſt needs be almoſt ſeve
nearer to us in one Poſition than in the other: For t
rent Magnitudes of far diſtant Objects increaſe or dec
pro

riods

in: for ſhe ne
whole Circle; a
im; which wo
ſe round the Ea
r. And this is
dnight, but alw
oſt not above th
r after Sun-ſetti
junction (or w
e Eaſterly than
d is ſeen after
nly called the E
her inferior C
, ſhe then app
to be ſeen in
called the *Ma*

ry turns round
bourhood, and
and therefore
on the accoun
ſeen without a

ppoſition, and
ith the Sun; he
d bright Face,
drat Aſpect, w
oon three or
he Orbit of ♂ a
Sun; for if he
nferior Conjun
ear, or appear
o in that Poſit
d A, P *Mars*, bod
n, and in both
res, when he ap
is plain hence,
otherwiſe he c
l that it like
r full at his C

n, looks almoſt
he is in Conju
almoſt ſeven t
ther: For the a
eaſe or decreaſe
propor

Plate X.

Fig I.

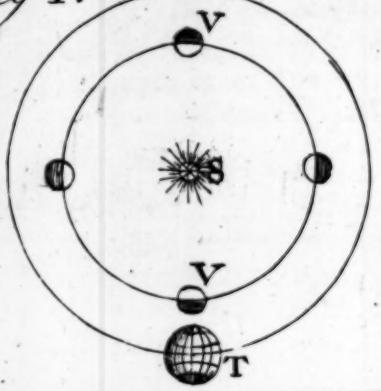


Fig II.

Fig IV.

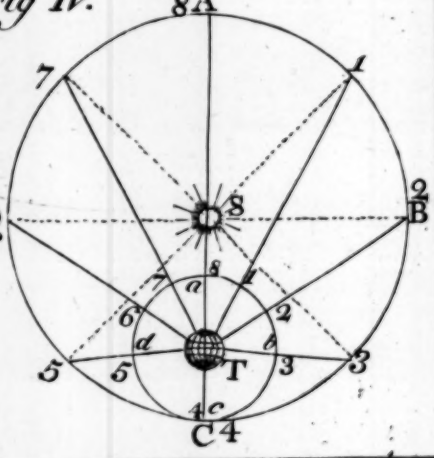


Fig V.

Fig VII.

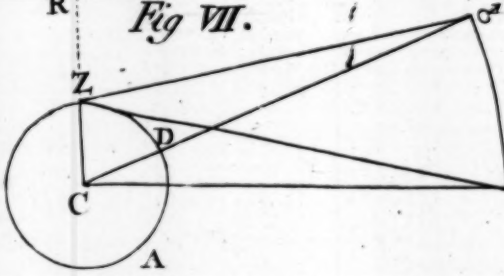
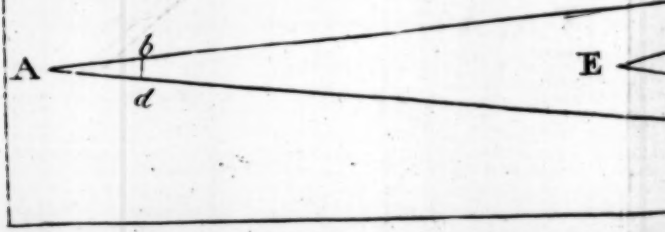


Fig VIII.



I.

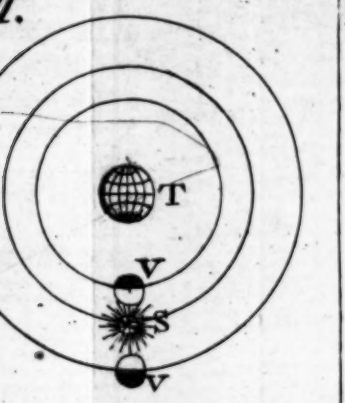
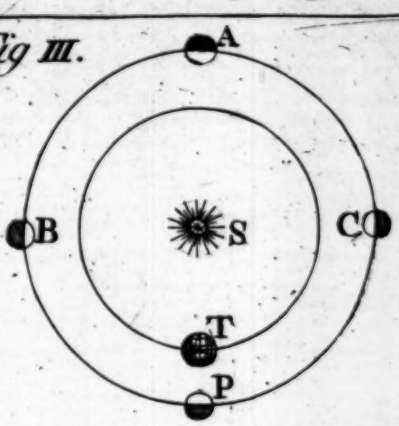
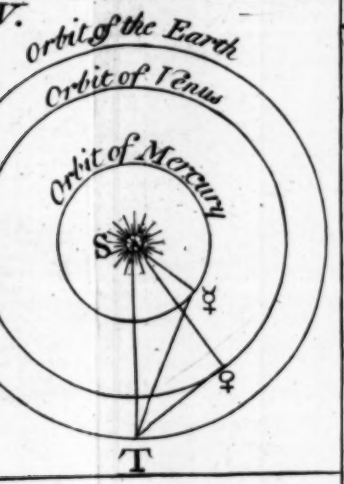
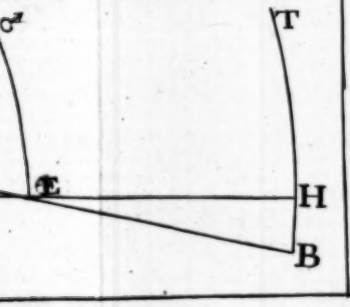


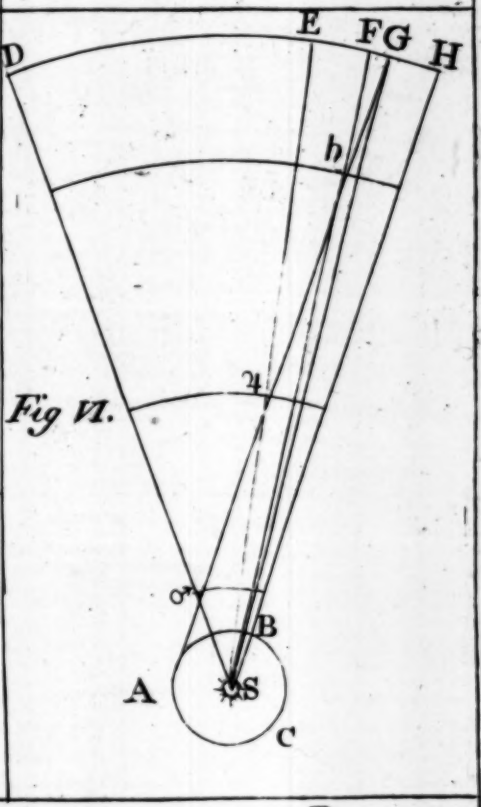
Fig III.

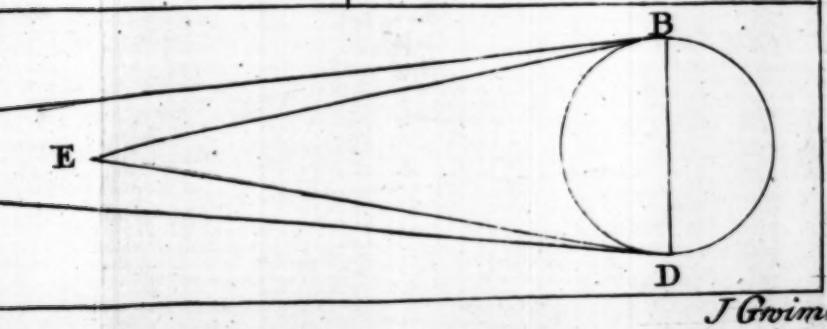


V.









J Gwinn

ion to their Diſtances from us. But *Mars* keeps always
t the ſame Diſtance from the Sun; therefore it is plain,
s not the Earth, but the Sun that is the Center of his

proved in the ſame way, that *Jupiter* and *Saturn* have
e Sun and the Earth within their Orbits, and that the
d not the Earth, is the Center of their Motions; altho'
proportion of the Diſtances from the Earth, is not ſo
Jupiter as it is in *Mars*, nor ſo great in *Saturn* as it is in
by reaſon that they are at a much greater Diſtance from

Inferior and Superior Planets.

ave now ſhewn that all the Planets turn
the Sun, and that *Mercury* and *Venus* are in-
between him and the Earth; whence they are
he *Inferior Planets*: and that the Earth is placed
n the Orbits of *Mars* and *Venus* and therefore included
the Orbits of *Mars*, *Jupiter* and *Saturn*; whence they are
he *Superior Planets*: And ſince the Earth is in the middle
moveable Bodies, and is of the ſame Nature with them,
conclude, that ſhe has the ſame ſort of Motions; but
turns round the Sun, is proved thus,

The Earth does not ſtand ſtill but turns round the Sun.

he Planets ſeen from the Earth appear to
ery unequally; as ſometimes to go faſter, at
imes ſlower; ſometimes to go backward, and
nes to be ſtationary, or not to move at all;
ould not happen if the Earth ſtood ſtill. Let
Sun, T the Earth, the great Circle A B C D,
bit of *Mars*, and the Numbers 1, 2, 3, *&c.* its
Motion round the Sun; the correſpondent Numbers
&c. in the Circle *a*, *b*, *c*, *d*, the Motion of *Mars* as it
be ſeen from the Earth. It is plain from this Figure,
the Earth ſtood ſtill, the Motion of *Mars* would be al-
progreſſive, (tho' ſometimes very unequal;) but ſince
ations prove the contrary, it neceſſarily follows, that
th turns round the Sun.

Fig. 4.

The Annual and Diurnal Motions of the Planets how computed.

Annual Periods of the Planets round the Sun
ermined, by carefully obſerving the length
e ſince their Departure from a certain Point
Heavens (or from a Fixed Star) until they ar-
the ſame again. By theſe ſorts of Obſerva-
he Antients determined the periodical Revolutions of
anets round the Sun; and were ſo exact in their Com-
ons, as to be capable of predicting Eclipſes of the Sun
oon. But ſince the Invention of Teleſcopes, Aſtrono-
Obſervations are made with greater Accuracy, and of con-
ce our Tables are far more perfect than thoſe of the An

tients. And in order to be as exact as poſſible, Aſtronom compare Obſervations made at a great Diſtance of time fr one another, including ſeveral Periods; by which means Error that might be in the whole, is in each Period ſubdi ded into ſuch little parts, as to be very inconſiderable. T the mean Length of a Solar Year is known even to Seconds.

The Diurnal Rotation of the Planets round their Axes, diſcovered by certain Spots which appear on their Surfa Theſe Spots appear firſt in the Margin of the Planets Disks, the Edge of their Surfaces,) and ſeem by degrees to creep wards their Middle; and ſo on, going ſtill forward, till t come to the oppoſite Side or Edge of the Disk, where t ſet or diſappear: and after they have been hid for the ſ ſpace of time that they were viſible, they again appear to in or near the ſame place as they did at firſt; then to creep progreſſively, taking the ſame courſe as they did before. T Spots have been obſerved on the Surfaces of the *Sun*, *Venus*, and *Jupiter*; by which means it has been found, that theſe dies turn round their own Axes in the times before-mentio It is very probable, that *Mercury* and *Saturn* have likewiſe a tion round their Axes, that all the parts of their Surfaces alternately enjoy the Light and Heat of the Sun, and rec ſuch Changes as are proper and convenient for their Na But by reaſon of the nearneſs of ☿ to the Sun, and ♄'s menſe Diſtance from him, no Obſervations have hitherto made, whereby their Spots (if they have any) could be di vered, and therefore their diurnal Motions could not be d mined. The diurnal Motion of the Earth is computed, fr the apparent Revolution of the Heavens, and of all the S round it, in the ſpace of a natural Day. The Solar Spots not always remain the ſame, but ſometimes old ones van and afterwards others ſucceed in their Room; ſometimes ſe ral ſmall ones gather together, and make one large Spot, a ſometimes a large Spot is ſeen to be divided into many ſm ones. But, notwithſtanding theſe Changes, they all turn rou with the Sun in the ſame time.

The better to conceive the apparent Annual and Diurn Motions of the Sun or the real one's of the Earth. Imagin Worm creeping ſlowly in the Ecliptic one degree forward, wh the Globe is turn'd once the contrary way, thus may the be ſaid to deſcribe each Day a Parallel to the Equinoctial, th properly 'tis a ſpiral Line, and yet is never out of the Eclipti but to repreſent to the Eye theſe Appearances as they truly ar Light a Candle in a dark Room, and take a ſmall Globe of or 3 Inches Diameter, in which mark the Poles, Æquator, an ſome Parallels with ſome Meridians paſſing from Pole to Po

en ſo hold this Globe before the Candle, that its Axis may
t be Perpendicular to the Plane of the Table, on which the
ndle ſtands; but let it be inclin'd to it in an Angle nearly of
½ Degrees, then place the Globe in ſuch a manner, that one of
Poles may point directly *North*, and let the Light of the Candle
ſt reach from Pole, to Pole that is, let the Circle bounding
ght and Shadow firſt paſs thro' the two Poles of the Globe, then
the Poſition of the Axis be well obſerved, and then move the
obe round the Candle, with your Hand in a Circle parallel
the Horizon, holding it ſo, that the Axis may always point
e ſame way, and retain the ſame Inclination to the Horizon:
is done, you will ſee that the Flame of the Candle will in the
ne manner illuminate this Globe, as the Sun actually does
e Earth, and the Poles of the Globe, its Æquator and Paral-
s will undergo the ſame Viciſſitudes of Light and
rkneſs.

How the Relative Diſtances of the Planets from the Sun are determined.

The Relative Diſtances of the Planets from the
n, and likewiſe from each other, are determined
the following Methods: Firſt, the Diſtances of
e two inferior Planets ☿ and ♀ from the Sun in
ſpect of the Earth's Diſtance from him, is had by
ſerving their greateſt Elongation from the Sun as
y are ſeen from the Earth.

Fig. 5. Elongation.

The greateſt *Elongation* of *Venus* is found by obſer-
tion to be about 48 degrees, which is the Angle
♀; whence, by the known Rules of Trigono-
try, the Proportion of S ♀, the mean Diſtance of *Venus* from
e Sun to S T, the mean Diſtance of the Earth from him, may
eaſily found: After the ſame manner, in the right-angled
iangle S T ☿, may be found the Diſtance S ☿, of *Mercury*
om the Sun. And if the mean Diſtance of the Earth from the
n S T be made 1000, the mean Diſtance of *Venus* S ♀ from the
n will be 723; and of *Mercury* S ☿ 387: And if the Planets
ved round the Sun in Circles, having him for their Center,
e Diſtances here found would be always their true Diſtances;
t as they move in Ellipſes, their Diſtances from the Sun will
ſometimes greater, and ſometimes leſs. Their *Eccentricities* are
mputed to be as follow, *viz.*

Eccent. of { *Mercury* 80 / *Venus* 5 / *Earth* 169 } of the parts abovementioned.

The Diſtances of the ſuperior Planets, *viz.* ♂, ♃, and ♄,
e found by comparing their true places, as they are ſeen from
e Sun, with their apparent places as they are ſeen
om the Earth. Let S be the Sun, the Circle A B C
e Earth's Orbit, A G a Line touching the Earth's

Fig. 6.

Orbit in which we'll ſuppoſe the ſuperior Planets are ſeen fr
the Earth, in the Points of their Orbits ♂, ♃, ♄; and let D
G H, be a Portion of a great Circle in the Heavens at an i
nite Diſtance: Then the Place of *Mars* ſeen from
Sun is D, which is called his true or *Heliocentric Pla*
but from the Earth he'll be ſeen in G, which is c
his apparent or *Geocentric Place*. So likewiſe *Jup*
and *Saturn* will be ſeen from the Sun in the Poi
E and F, their Heliocentric Places; but a Spectator from
Earth will ſee them in the Point of the Heavens G, which
their Geocentric Place. The Arches D G, E G, F G, the di
rences between the true and apparent Places of the ſuper
Planets, are called the *Parallaxes* of the Earth's annual Orb
ſeen from theſe Planets. If thro' the Sun we draw S H paral
to A G, the Angles A ♂ S, A ♃ S, A ♄ S, will be reſpecti
ly equal to the Angles D S H, E S H, and F S H; and the An
A G S is equal to the Angle G S H, whoſe Meaſure is the Ar
G H; which therefore will be the Meaſure of the Angle A G
the Angle under which the Semidiameter A S of the Earth's O
bit, is ſeen from the Starry Heavens. But this Semidiame
is nothing in reſpect of the immenſe Diſtance of the Heav
or Fixed Stars; for from thence it would appear under no ſe
ſible Angle, but look like a Point. And therefore in the He
vens the Angle G S H, or the Arch G H vaniſhes; and t
Points G and H coincide; and the Arches D H, E H, F H, m
be conſider'd as being of the ſame Bigneſs with the Arch
D G, E G, and F G, which are the Meaſures of the Angles A ♂
A ♃ S, A ♄ S; which Angles are nearly the greateſt Elongat
on of the Earth from the Sun, if the Earth were obſerved fro
the reſpective Planets, when the Line G ♄ ♃ ♂ A, touch
the Earth's Orbit in A. The nearer any of the ſuperior Pl
nets is to the Sun, the greater is the Parallax of the Annu
Orb, or the Angle under which the Semidiameter of the Earth'
Orbit is ſeen from that Planet. In *Mars* the Angle A ♂
(which is the viſible Elongation of the Earth ſeen from *Mar*
or the Parallax of the Annual Orb ſeen from that Planet) is a
bout 36 Degrees; and therefore the Earth is always to the In
habitants of *Mars* either their Morning or Evening Star, an
is never ſeen by them ſo far diſtant from the Sun, as we ſe
Venus. The greateſt Elongation of the Earth ſeen from *Jupite*
being nearly equal to the Angle A ♃ S is about 11 degrees.
In *Saturn* the Angle A ♄ S is but 6 degrees; which is not much
above ¼ part of the greateſt Elongation we obſerve in *Mercury*.
And ſince *Mercury* is ſo rarely ſeen by us, probably the Aſtrono
mers of *Saturn* (except they have better Optics than we have)
have not yet diſcovered, that there is ſuch a Body as our Earth
in the Univerſe.

Heliocentric and Geocentric Place what.

The

The Parallax of the Annual Orb, or the greateſt Elongation f the Earth's Orbit ſeen from any of the ſuperior Planets, be- g given; the Diſtance of that Planet from the Sun, in reſpect f the Earth's Diſtance from him, may be found by the ſame ethods as the Diſtances of the inferior Planets were. Thus, find the Diſtance of *Mars* from the Sun, it will be as the ne of the Angle ☉ ♂ A is to the *Radius*, ſo is the Diſtance S, (the Diſtance of the Earth from the Sun) to S ♂, that Di- nce from the Sun to *Mars*. After the ſame manner the Di- nces of *Jupiter* and *Saturn* are alſo found. The mean Diſtance f the Earth from the Sun being made 1000, the mean Diſtances, f the ſuperior Planets from the Sun are, *viz.* the mean Diſtance om the Sun of

♂	1524		141
♃	5201	and the Eccentricity	250
♄	9538		57

hich if we add to, or ſubtract from their mean Diſtances, we ll have the greateſt or leaſt Diſtances of thoſe Planets from e Sun.

There are other Methods, by which the relative Diſtances the Planets might be found; but that which has been here uſtrated, is ſufficient to evince the Certainty of that Pro- m.

How the Abſolute Diſtances of the Planets from the Sun are computed.

Hitherto we have only conſidered the Diſtances the Planets in relation to one another, without ermining them by any known Meaſure; but in der to find their abſolute Diſtances in ſome de- nate Meaſure, there muſt be ſomething given, oſe Meaſure is known. Now the Circumference he Earth is divided into 360 Degrees, and each of theſe Degrees o * 60 Geographical Miles, ſo that the whole Circumference ntains 21600; and by the known Proportion for finding the meter of a Circle from its Circumference, the Earth's Diame- will be found to be 6872 Miles, and its Semi- meter 3436 Miles. The Parallax of the Earth's idiameter, or the Angle under which it is ſeen m a certain Planet, may be found by comparing true Place of the Planet as it would be ſeen m the Center of the Earth, (which is known by Computa- n) with its apparent Place, as it is ſeen from ſome int on the Earth's Surface. Let C Z A be the th, Z C its Semidiameter, E ſome Planet, and

Parallax of the Earth's Semidiameter.

Fig. 7.

* *N. B.* 60 Geographical Miles are Equal to 69½ *Engliſh* Miles.

B H T an Arch of a great Circle in the Heavens, at an in nite Diſtance. Now the Planet E will appear from t Earth's Center C, in the Point of the Heavens H; but a S ſtator from the Point Z, upon the Earth's Surface, will ſ the ſame Object E in the Point of the Heavens B; and t Arch B H the Difference is equal to the Angle B E H = E C, the *Parallax*; which being known, the Side C E t Diſtance of the Planet from the Center of the Earth, at th time, may be eaſily found. Now if this Diſtance of the Pl net from the Earth be determined, when the Centers of t Sun, the ſaid Planet, and of the Earth, are in the ſame rig Line, we have the abſolute Diſtance of the Planet's Orbit fro the Earth's in known Meaſure: then it will be, as the re tive Diſtance betwixt the Earth's Orbit and that of the Plan is to the relative Diſtance of the ſaid Planet from the Sun ſo is the Diſtance of the Planet's Orbit from the Earth's known Meaſure, to the Diſtance of the ſaid Planet from t Sun in the ſame Meaſure: Which being known, the Diſtan of all the other Planets from the Sun may be found. For, will be, as the relative Diſtance of any Planet from the Sun, to its Diſtance from him in a known Meaſure; ſo is the r lative Diſtance of any other Planet from him, to its Diſtan in the ſame Meaſure. This may be done by finding the D ſtance of the Planet *Mars*, when he is in Oppoſition to the Sun after the ſame manner as we find the Diſtance of a Tree, o the like, by two Stations.

Let ♂ be *Mars*, D the Point on the Earth's Superficies, whe *Mars* is vertical, when he is in Oppoſition to the Sun, (whi may be exactly enough found by Calculation) at which time an Obſerver, at the Point Z, (whoſe Situation from D muſt known) take the Altitude of *Mars*, whoſe Complement will the Angle ♂ Z R; then in Triangle ♂ Z C will be given t Angles ♂ Z C, the Angle C whoſe Meaſure is the Arch D Z and conſequently the Angle Z ♂ C the Parallax, and alſo t Side Z C the Semidiameter of the Earth; by which we may fin C ♂ the Diſtance of *Mars* from the Earth. The extreme Nic ty required in this Obſervation, makes it very difficult to d termin the exact Diſtances of the Planets from the Sun; bu the celebrated Dr. *Halley* has, in the Philoſophical Tranſact ons, ſhewed us a more certain Method for finding the D ſtances of the Planets; which is by obſerving the Tranſit o *Venus* over the Sun.

How the Magnitudes of the Planets are determin'd.

The Eye judgeth of the Magnitudes of far d ſtant Objects, according to the Quantities of th Angles under which they are ſeen (which are calle their apparent Magnitudes;) and theſe Angles a pe

r greater or leſs in a certain Proportion to their Diſtances. herefore the Diſtances of the Planets from the Earth, and eir apparent Diameters being given, their true Diameters, nd from thence their Magnitudes) may be found. How the ſtances of the Planets may be found, has been already ſhewn; eir apparent Diameters are found by a Teleſcope, having a achine fixed to it for meaſuring Angles, called a crometer. Let B D, or the Angle B A D be the *Fig.* 8. parent Diameter of any Planet, and A B, or A D, hich by reaſon of the great Diſtances of the Planets in reſpect of their Magnitudes) may be conſidered as being the Diance of the ſaid Planet from the Obſerver. Now in the iangle A B D, having the Sides A B, A D given, and the An- A, we have alſo the other Angles B and D, (becauſe the les A B, A D are equal) whence the Side B D the Diameter the Planet may be eaſily found by Trigonometry.

From hence it appears, that the ſame Body at different Dinces, will ſeem to have very different Magnitudes: Thus, the ameter B D will appear, from the Point E, to be twice as ge as from the Point A. It alſo follows, that a ſmall Body, hen at no great Diſtance from us, may appear to be equal, even to exceed another at a great Diſtance, tho' immenſly gger. Thus *b d* appears under the ſame Angle, and conſeently of the ſame Bigneſs from the Point A, that the ne B D doth, tho' one vaſtly exceeds the other.

nd this is the Reaſon, why the Moon, which is uch leſs than any of the Planets, appears to us ſtly bigger than either of them, and even to eal the Sun himſelf, which is many thouſand times eater in Magnitude. *Why the Moon appears bigger than any of the Planets.*

The Diſtances of the Planets, and Periods round the Sun, eir Diameters and Velocities round their own Axes, *&c.* cording to modern Computations, are as follow in this.

Exact

	Saturn.	Jupiter.
Periodical Revolution of	Y. D. H. *l.* *ll.* 29. 174. 6. 36. 26.	Y. D. H. *l.* *l* 11. 317. 12. 20.
Daily Motion.	2 1	4.
Aphelion Anno, 1725.	♐ 27. 47. 0.	♌ 9. 4.
Ascending Node.	♋ 21. 45. 12.	♋ 7. 23.
Annual Motion of Node.	36.	
Greatest Mean Least Distance from ☉.	1008. 342. 953. 800. 898. 956.	545. 520. 494.
Eccentricity.	54. 700.	25.
Revolution about the Axis of Inclination of Orbit.	D. H. *l.* *ll.* 29. 10. 1. 16. D. 2. 30. 30.	H. *l.* *l.* 9. 56. D. 1. 22.
Bigger than our Earth times	298.	
Apparent Semidiameter.	*ll.* *lll.* 10. 30.	
Less than our Earth times.		
Heat near the Surface.	$\frac{1}{90}$	
Diameter in *English* Miles.	67. 870.	81.
Weight of Bodies on the Surface.	536.	
Density.	60.	
Quantity of Matter.	97.	
Parallax of Earth's Orbit. Greatest	6. 28.	11. 28.
Least.	5. 34.	10. 33.

That is a *Saturnian* Astronomer would never observe the Earth more than $6°.28^{l}$. nor less than $5°.34^{l}$. from the Sun in its farthest Elongations; so that it is hard to say, whether they or the *Jovial* Astronomer have yet discover'd that there is such a Body, as our Earth, or our Moon in the Universe.

SATURN is the highest Planet, has always a roundfull Face of a heavy dull Lead-colour, and may be Eclipsed by all the Planets, when in ☌ with him; every 378 Days is in Conjunction with the Sun, and has 5 Moons revolving about his Body which can be seen only with a very large Tube. ♄ has also a Ring or Belt surrounding him (like the Horizon of an Artificial Globe) and no where touching him, whose Plane is at this time nearly parallel to our Earths Æquator; but more exact

Mars.	Earth.	Venus.	Mercury.
D. H. *l.* *ll.*	D. H. *l.* *ll.*	D. H. *l.* *ll.*	D. H. *l.* *ll.*
321. 23. 27. 30.	365. 5. 48. 57.	224. 16. 49. 24.	87. 23. 15. 53.
31. 27.		1. 36. 7.	4. 5. 32.
0. 27. 0.	♍ 7. 35. 12.	♒ 4. 12. 0.	♈ 12. 53. 0.
18. 13. 0.	*ll.*	♊ 14. 35. 0.	♉ 15. 47. 0.
43.	Præceſs Equin. 50.	37.	1. 36.
{ 166. 385.	{ 101. 732.	{ 72. 791.	{ 46. 608.
{ 152. 369.	{ 100. 000.	{ 72. 333.	{ 38. 710.
{ 138. 199.	{ 98. 268.	{ 71. 729.	{ 30. 688.
14. 100.	1. 741.	517.	7. 970.
H. *l.*	H.	H.	H.
24. 40,	24,	23.	6.
D 1. 51.		D 3. 23. 0.	D 6. 54. 0. (as ſome ſuppoſe.)
	at ☉ 10.	*ll.* *lll.*	
4.		10. 30.	5.
15.		3.	27.
4 / 10.	1.	2.	7.
4. 444,	7. 935.	7. 906.	4. 240.
	1. 258.		
	387.		
	1.		
{ 36. 22.		{ 36. 32.	{ 25. 22.
{ 30. 34.		{ 35. 12.	{ 16. 47.

forms an Angle with the Ecliptic of about 31°, and its Diaeter is 2½ of *Saturn*'s Diameter, and the Diſtance of the Ring om the Planet, is about the Breadth of the Ring it ſelf, which ſome are call'd the Anſæ or Handles of *Saturn*. He is ſo r removed, that we cant behold his Spots. The Immerſions his (or ♃'s Satellites or Moons) can be ſeen only, when he is iental *i. e.* which is from ☌ to ☍, and their Emerſions when he is cidental or from ☍ to ☌, but if they be in exact ☌ to the). It will be in vain to look for either; the Shadow being caſt rfectly behind him.

♃*UPITER* is the next Planet to *Saturn*, has always a round ll Face, of a very fulgent and beautiful Aſpect, and may be lipſed by all the Planets, except ♄. ♃ is in ☍ with the ☉ very 398 Days, and has 4 Moons, which if obſerv'd with a

Teleſcope of only 2 Convex-Glaſſes, they always appear o the contrary Side of ♈.

Now the reaſon why *Saturn* and *Jupiter* have always a rou Face, is becauſe their illuminated Half is likewiſe turn'd towa the Earth as well as the Sun, becauſe the Earth ſeen from and ♈ is always near the Sun's Body, that is near the Cent of their Motions; but the Orbit of ♂ lying near our Ear his Face which is towards the Sun will not always be turn towards our Earth, this cauſes his Increaſe and Decreaſe Light.

Becauſe ♃ is 5 Times further off the Sun, than the Earth the apparent Diameter of the Sun ſeen from *Jupiter* will 5 times leſs, than it is ſeen from the Earth, and will be bigger than 6 Minutes, to ♃, which to us is 30', and the Disk of Sun will appear 25 Times leſs than it does to us, who likewiſe receive but the 25th part of the Light and Heat fr him that we enjoy. But *Saturn* being 10 Times farther from Sun, than we, the apparent Diameter of Sun ſeen from him be no bigger than 3 Min. and will be but little more than t the Diameter of ♀, when ſhe approaches neareſt to the Ear and therefore the Disk of the Sun, as it would appear to *turnian* Aſtronomer will be 100 Times leſs than we ſee it, both its Light and Heat are there diminiſhed in the ſame Propo tion, and therefore the neareſt Regions in *Saturn*, even un his Æquator are ſuppoſed much cooler than our Frigid Zon

MARS moves between the Earth and *Jupiter*, is of a fi red Color, and ſuppoſed to have an Atmoſphere; becauſe Fixed Stars when near his Body appear obſcur'd, and s were extinct, when in ☌ to ☉ he is very near our Earth, his horizontal Parallax 37''. 34'''. and is 2 Years, and 50 D between every Conjunction with the ☉. ♂ increaſes and creaſes in Light like our ☽, and in his Quadratures is alm biſected, and when he is in Perigeon or ☌ he is 7 Times ne er the Earth, than in Apogee or ☍ with ☉, and is there 7 Times bigger and brighter yea he is nearer us, than ♀, ☿, ☉ himſelf. In 1656, was obſerv'd to have a broad obſcure Zon or Belt to Shadow near half his Disk, he may be eclipſed by Sun. ♀ ☿, and ☽.

Mars. In his neareſt Approach to the Earth, was moſt accur obſerv'd, and his Parallax determin'd to be 30'', from whe the Sun's Parallax is ſcarce 11'', and his Diſtance about 19000 S midiameters of the Earth.

Mars always keeps nearly at the ſame Diſtance from the Su but not from the Earth; therefore the Sun, and not the Ear is the Center of his Motions the ſame may be ſaid of *Jupi* and *Saturn*.

T

The Earth has one Satellite, *i. e.* our ☽, has a Conical Shadow, whose Vertex reaches not so far as the Orb of *Mars* at a mean distance, the length of the Earth's Shadow is 214 Semidiameters and the Moon's Shadow, but 58, and the Height of the Atmosphere 47. 12 *English* Miles.

An Inhabitant of the Earth observes the Sun, which is really immoveable to go thro' the same Circle in the Heavens, and in the same space of Time, that a Spectator in the Sun would see the Earth describe, and the like in all the other Planets *mutatis mutandis*; thus one in ♅ would think the Sun turns round him in 12 Years, and one in ♄ in 30 Years, and in different Circles, since therefore 'tis impossible that the Sun can have all these Motions really in it self we may safely affirm, that there are none of them real, but that they are all apparent, and arise from the Motions of the Earth, and other respective Planets.

VENUS moves in an Orb between the Earth and ☿. She is the most splendid of all the Planets, and is a Year and 219 Days between one Conjunction, and another with the ☉ of the same kind, that is ♀ is conjoyn'd with the Sun in the Superior part of her Orb, when she is in Apogæon direct, and always Oriental, but when conjoyn'd with the Sun in the lower Part, she is in Perigeon, and Retrograde, and if her Latitude be less than the ☉'s apparent Semidiameter, she will then appear a black Spot in the Sun's Disk, the like of ☿; but between a Direct ☌, and Retrograde ☌ with the ☉, are only 300 Days; in the last, she is 6 Times nearer us, than the first, even the Diameter of her Orbit: when she becomes Retrograde, she is always Occidental of the ☉. Every 8 Years she is nearly in the same Place again, when she is Occidental, and near her Perigeon at her greatest Elongation from the Sun, she shines so bright, as to cast a Shadow, and shine in the Day-time, as she did 1630, *May* 29. at the Birth of King *Charles* II. she appears horn'd, Gibbous and Full, and increases and decreases in Light, as our ☽. In *May* 26th, in the Year 1761. ♀ will pass by the Body of ☉, whence the Sun's Distance may be ascertain'd within $\frac{1}{300}$ part of thewhole.

MERCURY being so near the Sun, is seldom seen, and in the space of 13 Years may be found nearly in the same Place, and is 115 Days between one mean ☌ with ☉. and another of the same kind, the Color of *Mercury* somewhat resembles that of *Mars*, and is too near the Sun, to discover many of his Spots, in so much that some yet question, whether he turns about his Axis.

That *Venus* and *Mercury* in ☌ with ☉ by a Retrograde Motion pass between the Earth, and ☉. this could not be, if the Earth were the Center of the Universe.

That ♀ is never more than 48°. and ☿ never more, than 28° from the Sun, which could not be, if the Earth were at rest in the Center of the Universe.

IV. *The Chief* Phænomena *of the* Sun *a*

I. The Sun's Center is obſerved to move eve Year in the ſame Plane, or Ecliptic-line, and is nev found to change its Courſe.

Becauſe by the Laws of Nature, the Earth is always mo in that Plane about the Sun.

II. The *Sun* appears to be moved unequally, be Swifteſt after the *Winter* Solſtice, and Sloweſt af the *Summer* Solſtice.

For the Earth is moved about the Sun, not in a Cir but an Ellipſis, which hath the Sun in one of its Focus evident, becauſe there are about 8 Days Difference betwixt Motion from ♈ to ♎, and that from ♎ to ♈.

III. The apparent Diameter of the *Sun* is great in *Winter*, when his Motion is Swifteſt, than it is *Summer*, when his Motion is Sloweſt.

Becauſe in *Winter* he is in Perigee, or neareſt the Earth, in *Summer* in Apogee, or fartheſt from it. Hence the Diame muſt alter in Proportion to its Diſtance, and ſeeing the Su apparent Motion, and apparent Diameter, are found to anſw to the Diſtance of the Earth from the Sun, when the ſame computed, according to an Ellipſis, and not according to Eccentric Circle, we eaſily gather, that the Orbit of the Ear is not properly Circular, but Elliptical.

IV. Thoſe Places of the Ecliptic, in which the Di ference of thoſe apparent Motions, and Diameter are greateſt, are chang'd in Proceſs of Time, and th always with an even Motion, and towards the Co ſequent Signs.

Becauſe the Apparent Motion of the Aphelion of the Earth is found to be Equal to the Annual Motion of the Equinoctial Points, the Moderns have for very good Reaſon ſuppoſed th

Aphelia

helia of the Stars to be unmoved with reſpect to the *fixed* s. but allow they appear to advance as faſt as the Equi-ctial Points go back.

V. The Ecliptic being divided into two equal Parts the Equinoctial Points, the *Sun* makes a longer y, by about the Space of 8 Days in the *North* part, m *Spring* to *Autumn*, than it doth in the *South* rt from *Autumn* to *Spring*.

ecauſe the upper Part of the Ellipſe is not only conſidera-larger, but the Sun's apparent Motion ſlower than in the r Part of the Ellipſe, hence the Sun muſt needs appear more s in the *Northern* than in the *Southern* Signs; 'tis here worthy ice, that this Inequality of about 8 Days is different from t it was in *Ptolomy*'s Time, and will continually decreaſe, at length vaniſh for a Time, and then encreaſe and decreaſe rnately, ſo long as the annual Motion ſhall endure, being reſt when the Line of the Solſtices coincided with the long-xis, and nothing when it coincides with the Shorter.

VI. Yet is the Space of one entire Revolution, ch we call a Year equal to it ſelf, or the ſame one r, that it is another, conſiſting of 365 Days, 5 urs, 48^{1}, 57^{11}.

though there be an Inequality in the Parts of this Revolu-, as compared amongſt themſelves, yet ſeeing one Part gives the other looſes, and this Inequality is always in the ſame , the Quantity of the whole Revolution muſt neceſſarily ways the ſame.

VII. The Declination of the Ecliptic from the ator hath been found nearly the ſame in all Ages about $23^{\circ}\frac{1}{2}$.

o' it was accounted ſome Minutes more by the Antients, it hath been by the Moderns, probably occaſion'd by the curacy of their Inſtruments, and too general Neglect of ctions, Parallaxes, *&c.* yet by Modern accurate Methods, eclination appears always the ſame, and unvaried for what d diſturb the Earth from keeping that Angle perpetually, hich it was once conſtituted.

VIII. The

VIII. The Diurnal Parallax of the *Sun* is almoſt
ſenſible, and its Menſtrual ſcarce ariſeth unto
quarter of a Degree.

The Parallax of the Sun, may be found three ſeveral W
1ſt By the Diagram of *Hypparchus* uſed by all the Antient A
nomers, who like Surveyors attempted to find the Suns Di
by two Stations, in each of which they noted its Diameter,
upon the Earth, the other at the top Point of the Shadow,
no wonder if they fail'd in the Attempt: yet hence we l
that the Sun's Parallax is ſo very ſmall, as to elude all Atte
this way, it conſiſting rather of Seconds than Minutes,
that its Diſtance is ſo immenſly Great, that it is to be rec
not by a few Miles; but many thouſand Semidiameters o
Earth.

2d Is by Obſervation of the ☽ in her exact Quadratures
by *Kepler*, *Vendeline*, *Ricciolus*, which is an excellent Method, and
poſes the Semidiameter of ☽'s Orbit equal to 60 Semidiam
of the Earth might bear ſome ſenſible Proportion to the
Diſtance tho' a ſingle Semidiameter did not. *See Plate the*

N. B. The Menſtrual Parallax of ☉ is the Difference of P
on there is in the ☉, as ſeen from the Earth. and as ſeen
the ☽ in this Method the preciſe Moment of Biſection of th
and the preciſe Places of the ☉ and ☽, eſpecially the la
ſo difficult to obtain to that Exactneſs neceſſary to dete
Difference only of a few Minutes occaſion'd our beſt Aſtr
mers to recur to.

The 3d. which is by far more exquiſite, *i. e.* by the Obſerv
of the Parallax of ♂ (or ♀) diſcover'd by *Caſſini*, and
braced and confirm'd by *Dela Hire*, *Flamſteed*, and others,
found the Parallax of ♂ 25″ of the ☉ 10″, hence his
ſtance is about 81 Millions of Miles, and his Diameter 50
Miles.

IX. That this *Sun*, who is the Center of Gr
and Fountain of Light and Heat, revolves about
own Axis in the Space of 27 Days, appears from
Spots; which have taken 13½ Days from the Time
their Appearing or Riſing on the *Eaſt* Limb, to t
Setting on the *Weſt*, and after Setting, being hid
abſconded in the oppoſite ſide of the *Sun*, for

Space of 13½ Days have again appear'd, and took ſame Courſe as before.

X. Since in *Summer* we are farther from the *Sun*, when *Winter* comes on, we begin to approach rer to him, is it not a Wonder then ç that the rth grows warmer, while it is ſtill further removing n the *Sun*, and again in the *Winter*, why it ſhould colder notwithſtanding its nearer Acceſs to him.

B. The Degrees of Heat and Cold depend not altoge- upon the Diſtance from the Sun, but there are other power- nd concurring Cauſes, as the direct force of the ⊙'s Rays in *mer* is much Stronger than when they are received Oblique- n *Winter*, moreover there are much fewer Rays, which render Light not ſo denſe, nor the Heat intenſe, as in Fig. 4. Plate I. A repreſent the ⊙, DICK *&c.* Parallel Rays of Light ing from the ⊙. Let L M repreſent ſome Space on the h's Surface, to which Place the ⊙ is Vertical, the Rays will Perpendicular, and take up the Space C K. But let the ⊙ emoved from a Perpendicular Poſition, as ſuppoſe E F here ſame Quantity of Rays will take up the Space K b. but let e removed yet further from a Perpendicular Poſition as there the ſame Quantity of Rays will take up the Space , and conſequently it muſt be colder in the Laſt, than in Second, and in the Second than in the Firſt.

lſo the Sun being low, near, or in the Horizon all *Winter*, Beams paſs thro' a much greater Quantity of Air, than in *mer*, and the force of the Rays is broke by the Reflections o many Particles of Air, and this Difference is ſo very Great, when the ⊙ is in the Horizon, we can look upon him with- hurting our Eyes, but when he riſes higher there is no endu- his Sight without blinding us.

o this add another powerful Cauſe, which is, that the long- ny hard and ſolid Body is expoſed to the Fire, the hotter it ws. Now in the *Summer*, for 16 Hours, we are continually he ⊙'s Heat, we have only 8 Hours to cool; the Con- y, of which happens in the *Winter*, and therefore it can be Wonder, that there ſhould be ſo great a Difference of Heat Cold in theſe two Seaſons.

or why we ſhould have the greateſt Heat about the End *uly* tho' the Sun has been leaving us above a Month, for Action of the Sun, by which all Bodies are heated, is not nſient, as its illumination is, but Permanent, ſo that a Bo-

dy

dy once heated by the Sun, retains its Heat for ſome Time a
the Sun have gone off it, but afterwards, when theſe hea
Particles fly off, or loſe their Force, the Body begins to co
and therefore if the heating Particles, which are conſta
receiv'd be more than they, which fly away, or loſe their Fo
the Heat of the Body muſt continually encreaſe. Thus after
☉ has entred the Tropic, the Number of Particles, which
our Atmoſphere does continually encreaſe, there entring m
in the Day-time, than what we looſe in the Night-time,
therefore our Heat muſt grow greater. But then as the D
decreaſe, and the Action of the Sun becomes weaker, both
cauſe of his ſhorter Stay, and the Obliquity of his Rays,
there will at laſt be more Particles, that fly away in the Ni
time, than what we receive in the Day-time, by which m
the Heat of the Body will grow every Day leſs, and the E
and Air, will by degrees cool.

V. *The Inveſtigation of the* Sun's *Entring the* Equa

In or near the Equinoxes, with a large and exact Inſtrum
take the Meridian Altitude of the Sun, if it be equal to
Complement of the Latitude, the Sun is that Moment in
Equator, but if it is not equal, take the Difference, which wi
the Sun's Declination, then the next Day obſerve again
Meridian Altitude, and gather from thence his Declinatio
theſe two Declinations be of different Kinds, as one *South*, th
ther *North*: the Equinox happens ſometime between the two
ſervations, or if they be both of the ſame Sort, the Sun ha
ther not entred the Equinoctial or has paſt it.

Now each Day having the Suns Declination afore found,
his Longitude anſwerable for the Day before, and the Da
ter the Equinox, both which Longitudes add, and ſay as
Sum is to 24 Hours, ſo is the firſt found Longitude to
Number of Hours, and Minutes between the firſt Obſerva
and the Moment of the Sun's Ingreſs to the Equinoctial.

VI. *The* Phænomena *of our* Moon.

As the D by reflecting Light from the Sun illuminates
Earth, ſo the Earth does more than repay her Kindneſs in
lightning the Surface of the Moon by the Sun's reflex L
which ſhe diffuſes more abundantly upon the Moon, tha
Moon does upon her; about 50 Times more, our Earth ap
ing to the D, 50 Times bigger than the D to us. In New

e illuminated Hemiſphere of the Earth is fully turn'd towards e Moon, to illuminate the Moon's dark Hemiſphere, and en the Lunarians will have a full Earth, as we in a ſimilar ſition, have a full Moon, from whence ariſes that dim Light, hich we ſee in the Obſcure Part of the Old and New Moon; hereby, beſides the bright and ſhining Horns, we can perceive e reſt of her Body.

2. The Light of the Moon is ſo very weak, even in e Full, that the leaſt Heat could never be perceiv'd om it, the Moon's Light has been computed to be more than $\frac{1}{300000}$ Part of the Suns Light, and if the n's Light be 7 Minutes coming to us, the Moon's ill come in 2^{11}. and 49^{111}.

3. The Moon may be obſerv'd in her higheſt Altide, greater than the Sun's greateſt, and in her weſt Altitude, lower than the Sun's loweſt Meridian Altitude; becauſe of her Latitude of above 5°, ther *North* or *South*, and the Moon's Denſity is 7 imes the Denſity of the Sun, alſo if the Sun's Diaeter be 763,460 Miles, the Moons Diameter is but 175.

4. *'Tis Probable the* Moon *has no Atmoſphere about r*: For the Planets and Stars, which are ſometimes en very near her Limb, have not their Light refract-, as it is when it paſſes thro' our Atmoſphere, moreo-r, when there are no Clouds in our Air, the Moon nſtantly appears with the ſame Luſtre. Hence we ay ſuppoſe no Clouds nor Vapours in the Moon, hich would obſtruct ſome of its Regions from our ght, which we never obſerve them to do; yet ſome gue from the great Eclipſe, *April* 1715, that it as an Atmoſphere, becauſe one might bear looking the Sun, while the Eclipſe was coming on, for the ays came then by that Side of the Moon, on which e Sun had lately ſhone, and conſequently had raiſed me Vapours there, which muſt needs weaken the

Sun's Rays; but when the Moon was going from th Sun, then looking to the Sun was not tolerable, th Eye being dazled, but the Rays, which pafs'd by th Side of the Moon, on which the Sun had not ſhon for near 15 Days, which made the Atmoſphere ver clear of Vapours.

5. *A* Synopsis *of the Motions of the Earth's* Satellite, *or Our* Moon.

	D.	H.	*l.*
Periodic Revolution about the Earth and about her Axis.	27.	7	43.
Synodical Revolu. Earth in Perihelion	29.	19.	
Synodical Revolu. Earth in Aphelion	29.	7.	
Inclination of her Orbit.	Deg.	5.	18.
	Y.	D.	
Revolution of the Nodes, and Period of Eclipſes.	18.	224.	3.
But according to *Whiſton*, for the mean Time of the Return of Eclipſes.	18.	11.	7. 43.

Diurnal Motion in Longitude.	Deg.	13. 10.
Diurnal Motion in Anomaly.	Deg.	13. 3.
Diurnal Motion in ☽'s Apogeon.		6.
If her mean Diſtance from Earth be.		100.
Then her Apogeon Diſtance is		107.
Then her Perigeon.		92.
Then her Eccentricity.		7.

Leſs than our Earth Times.		50.
Earth's Semidiameter. at mean Diſt. is.		1.
Moon's Semidiameter. at mean Diſt. is.		
		l.
Horizontal Parallax in Apogeon.		52.
Horizontal Parallax in Mean Diſtan.		56.
Horizontal Parallax in Perigeon.		61.
Apparent Semidiameter in Apogeon.		14.
Apparent Semidiameter in Mean Diſt.		15.
Apparent Semidiameter in Perigeon.		16.

The

6. The Moon revolves continually from *Weſt* to *Eaſt*, nd this almoſt in the ſame Line with the Sun, which e call the Ecliptic.

Yet, this notwithſtanding, it is not moved exactly in the me Line with the Sun, for ſometimes it declines ſeveral Degrees more from the Equator, than the Ecliptic doth, and metimes ſeveral Degrees leſs.

7. The Moon ſeems daily to put on a new Face, metimes 'tis Inviſible, and when it becomes Viſible, it ppears firſt Horned, then Biſected, then Gibbous, hen Round, and then puts on the ſame Shapes again, t in an Inverſe Order.

For that Half of the Moon's Body next the Sun is enlightd by him, whilſt the other oppoſite Half is involv'd in Darkſs, which is turn'd wholly to us in the new Moon, as the lightned Half is wholly facing us in full Moon, betwixt hich we ſee more or leſs of the light Hemiſphere, and accordgly ſhe appears Gibbous, Biſected, or Horned.

8. 'Tis obſerv'd, that the Sun is Eclipſed, when the oon is Inviſible, and never elſe, and that the Moon elf is Eclipſed, but never elſe but when 'tis Round.

9. The Dark part of the Moon, both when 'tis Hord, and when either it ſelf, or the Sun is eclipſed not wholly Inviſible, but yields a certain dim, diſal, and reddiſh Light, probably occaſion'd by the flected Light from our Earth aforeſaid.

10. The Eclipſes both of Sun and Moon, do not hapn every Year in the ſame Places of the Zodiac; t in Places removed from the former gradually toards the Antecedent Signs.

Becauſe the Nodes go backward every Year.

11. The apparent Diameter of the Moon is not alys the ſame, but Greater and Leſs by turns, and this

with a Difference very ſenſible, *according to her different Diſtances from us.*

12. The apparent Motion of the Moon, is not always equal, but Greater and Leſs by turns, and likewiſe with a Difference very ſenſible.

Becauſe of the Elliptic Figure of her Orbit, and Change of its Eccentricity.

13. The Moon's Daily Motion is ſwifteſt (*Ceteris paribus*) in the Conjunctions with, and Oppoſition to the Sun, and ſloweſt in the Quadratures.

Becauſe the Eccentricity is abſolutely the greateſt in the Conjunction of the Apſides.

14. The Place where the Moon appears the leaſt and its Motion the ſloweſt, is not always found in the ſame Degree of the Ecliptic, but removes into the Conſequent Signs.

Becauſe the Apſides advance towards the Conſequent Signs.

15. The Latitude of the Moon is mutable, ſometimes Greater, ſometimes Leſs in the ſame Degree of its own Longitude, according to its various Situation with reſpect to the Sun.

This Inequality of the Inclination of Moon's Orbit, is owing to the Regreſs of the Nodes.

16. The Orbit of the Moon, ſometimes approaching in ſome Meaſure unto the Circular Figure, otherwhile again recedes from the ſame, according to its divers Situation with reſpect to the Sun.

Becauſe of the Change of its Eccentricity.

17. The Motion of the Moon is very unequal, nor is it like to it ſelf, whether we compare divers Parts

the ſame Month, or the like Parts of divers Months.

And truly no Wonder, becauſe of the various Changes of Excentricity, Apogee, Aphelia, Nodes, true Velocities, Variations no way connected together among themſelves.

18. The Moon is always found to paſs betwixt the Earth, and the reſt of the Stars, whether Fixed or Erratic, nor has it ever been obſerved, that any Star paſs'd betwixt the Earth, and the Moon.

The ſame Face of the Moon, is in general always turn'd to the Earth; yet are there various Librations of the ſame Face, ſome Parts are diſcovered, and hidden alternately.

The firſt Part is plain from its Diurnal Motion about its Axis in the very ſame Space of Time, as is the Periodic Month; whereby as much of its Face is turn'd to us, as is turn'd away from us by the menſtrual Motion *nearly*, which ſometimes is greater, and ſometimes Leſs, and we viewing it from the Focus of a variable Ellipſe occaſions thoſe reciprocal Librations; to which add the Conſideration of the Inclination of the Plane of the Moons Equator, to that of its Orbit.

III. *To find the* Parallax *of the* Moon.

In an Eclipſe of the Moon, obſerve when both the Horns are in the ſame Vertical Circle, and then at that Moment, take the Altitudes of both Horns, the Difference of theſe two Altitudes being halved, and Added to the leaſt, or Subtracted from the Greateſt does give nearly the Viſible Altitude of the Moon's Center; but the true Altitude, is nearly equal to the Altitude of the Center of the Shadow at that Time. Now we know the Altitude of the Center of the Shadow; becauſe we know the Place of the Sun in the Ecliptic, and its Depreſſion under the Horizon, which is

is equal to the Altitude of the oppoſite Point of the Ecliptic, in which is the Center of the Shadow, and therefore we have the true Altitude of the Moon, and the apparent Altitude, whoſe Difference is the Parallax, which will therefore be known.

By the apparent and real Longitude of a Phænomenon, the Parallaxes may be inveſtigated, the apparent Longitude is found by obſerving the Diſtance of a Phænomenon from two Fixed Stars, whoſe Longitudes and Latitudes are known, and the true Longitude is had by making the ſame Obſervations, when the Star is in the 90th Degree of the Ecliptic, where the apparent, and true Longitude coincide.

COROLLARY.

Thoſe who can attentively View the Wonderful, Beautiful, and Admirably contrived Structure of this our adjoyning Planet, with its Sea and Land, Mountains and Valleys, Day and Night, *Summer* and *Winter*, together with its Clouds and ſuppoſed Atmoſphere, all in Correſpondence to our Earth, which is every where full of intelligent Beings, its Inhabitants; and yet ſhall peeviſhly deny, that it either now is, or ever was, or is to be in like manner inhabited by ſuch intelligent Beings, and are reſolv'd, it ſhall have no other Uſe, than to enlighten our Earth, and be peep'd at thro' our Teleſcopes, ſeem to me too Unphiloſophical to be argued with.

K. The Doctrine of ECLIPSES explain'd, and more fully conſider'd than in Page 135. &c.

1. All Opake, and Dark Bodies, when expoſed to the direct ght of the Sun caſt a Shadow behind them, that is oppoſite the Line the Sun is in.

2. This Shadow is nothing, but the Loſs, or Privation of ht in the Space oppoſite to the Sun, by reaſon the Sun's Rays intercepted by the Opake Body.

3. Since the Earth is an Opake Body, it muſt likewiſe caſt a dow towards the ſpace Oppoſite to the Sun, in which Space, he Moon ſhould come, it muſt neceſſarily be darkned, and the Light, which it had before from the Sun.

4. Becauſe the Earth is Spherical, the Figure of the Shadow uld be Cylindrical; if the Earth and the Sun were of equal neſs, or if the Earth were bigger than the Sun, the Shadow uld have the Figure of a Cone, which had loſt a Piece at Top or Vertex, and the farther it were extended would w thicker and thicker.

5. In both theſe Caſes, the Shadow would run out into in- te Space, without ever having an End, and then it would olve ſometimes the other Planets ♂, ♀, and ♄ within it, en they come to be oppoſite to the Sun, and enter within t Space. But this is never obſerv'd, for then theſe Planets uld be eclipſed.

6. Therefore the Sun muſt neceſſarily be greater than the th, whoſe Shadow muſt conſequently be of a Conical Figure, end in a Point before it reach any of the other Planets: e ſame Way of Reaſoning may be applied to the Moon, ich alſo has a Shadow of a Conical Figure, into which when Part of the Earth doth come, that Part is thereby depriv'd of Sun Beams, and to the Inhabitants thereof, the Sun appears ipſed.

7. Beſides the Shadow, which is deprived of all the Sun's ht there is a certain Space all round it, which is but a par- Shadow, and is called a Penumbra, for tho' all the Sun's dy does not illuminate it, there are for all that Rays coming from

from ſome part of the Sun, which do enter it, and render it ... cid, the reſt of the Sun Beams being intercepted by the O... Body, and the Parts of this Penumbra will have different ... grees of Illumination, according as they are nearer or further ... moved from the Shadow, the nearer the Shadow, ſo much ... Darker.

8. The Height of the Earth's Shadow, at a mean Diſtan... 214. 8 Semidiameters of the Earth, and the Height of the Mo... Shadow; but 59. 36 Semidiameters, being in Proportion to ... other, as the Diameter of the Earth to the Diameter of ... Moon *i. e.* as 100 to 28.

9. If the Diſtance of the Moon from the Earth, be gre... than her mean Diſtance, which is about 60 Semidiameters of ... Earth, the Shadow of the Moon can't reach the Earth, in which ... there may be a central Eclipſe of the Sun, but not a Total ... For round the Moon, there will appear part of the Sun's B... in the form of a Luminous Circle, which like a bright ſhin... Ring of Gold, will embrace the Body of the Moon, this P... nomenon is call'd an Annular Eclipſe of the Sun.

10. Theſe Annular Eclipſes happen when at ☌ the Moo... near her Apogee, and the Sun near his Perigee, then may ... apparent Diameter of the Sun, a little exceed that of the M... and ſuch an Appearance *Clavius* obſerv'd at *Rome*, on the ... Day of *April* 1567.

11. If in the Time of the Eclipſe, the Moon's Anoma... leſs than 3, and more than 9 Signs, there can no where ... total Eclipſe of the Sun, for in all theſe Degrees of Anom... the Diſtance of the Moon is greater than her mean Diſtanc...

12. In total Eclipſes of the Sun, when the viſible Diam... of the Sun and Moon, are equal at viſible ☌, then no ſooner ... Sun's Light ſhall ſhut on the *Eaſt* Side, but it emerges on the ... Side, and if the Moon's apparent Diameter be greater than ... of the Sun, then will the total Darkneſs continue ſome Min... never above 5 Minutes in any one place.

13. In Lunar Eclipſes, if the Sum of the Moon's Lati... and Semidiameter be { Greater than, / Equal to, / Leſs than, } the Semidiamer... the Earth's Shadow the Eclipſe will be { Partial, or leſs than / Total, or equal to / Total with Continuance or above } 12 Degits.

14.

. The Moon is never properly obſcured by the Shadow of Earth it ſelf, but by the Earth's Atmoſphere, becauſe the s of Light, which paſs thro' the Atmoſphere next to the n enter the Atmoſphere, and from thence go out again, whilſt they paſs out of the Earth into the Atmoſphere, is out of a rare Medium into a Groſſer one, they muſt ne-rily according to the known Laws of Refraction, incline he Perpendicular Rays, and when they paſs out of the oſphere into the Earth again, they muſt recede from the endicular, but both in the one Caſe, and the other, they incline towards the ſame Part, or towards the Axis, (by n of the Change of the Perpendicular) which double Re-ion computed, it appears, that the Solar Rays, which paſs to the Surface of the Earth are ſo bent, that they meet to-er in a Point long before they reach the Diſtance of the n.

. But then thoſe Rays, which paſs thro' the upper part of Atmoſphere, ſeeing they are ſubject to leſs Refraction, will ſo ſoon meet together in a Point, but they will have d far beyond the Moon firſt, and thus it is, that the Eclipſe e Moon is cauſed, in which conſequently the Moon is not er'd wholly inviſible, but only of darkiſh Hue, the Ter-ial Atmoſphere bringing that kind of Obſcurity whilſt on ne Hand it deadens, and wholly ſtops the greateſt Part of Solar Rays, and on the other tinges the reſt with a dark k direful Color.

. The middle Time of Eclipſes, or the neareſt Approxima-of the Centers of the Sun and Moon is not the very Mo-t of the New or Full Moon; but a little before or after, rding to the Moon's Latitude and Poſition of the Nodes. conſider, if the Sun were moved in the Ecliptic, in the n while, that the Moon reſted in her own Orbit, the mid-loment of Eclipſes would be in a plane Perpendicular to Ecliptic: Again if the Moon were moved in her Orbit, the being unmoved in his Orbit, then the ſaid Moment ld be in a plane Perpendicular to the Lunar Orbit; but oth the Sun and Moon be moved, and with unequal Ve-y (as 13 to 1) then the middle Moment muſt partake of Conditions, and conſequently be in ſome Plane, which terpoſed betwixt the two former, and that 13 Times nearer Perpendicular to the Lunar Orbit, than to the Perpendi-r to the Solar Orbit or Ecliptic; but this Difference, the enious *Flamſteed*, has prudently removed, by his Table of

the Angle, made with the Ecliptic, by the Motion of the Mo from the Sun, which becauſe it reſpects the moveable C ters of the Sun, and of the Earth's Shadow determines the A gle always greater, than the greateſt Inclination of the Lu Orbit to the Ecliptic.

17. The Difference betwixt Eclipſes of the Sun and Mo in ſundry Particulars follow. The Eclipſe of the Moon has ſame Appearance to all the Spectators, at the ſame Inſtant; the Eclipſe of the Sun may appear in one part of the Earth tally obſcured: in another, but in part on its *North* Side: 3d, on its *South* Side; and in many other Places, no Eclipſe all; and all this at the ſame Moment of Time.

18. Hence Eclipſes of the Moon, may be reduced to an ther Meridian, by allowing the Difference of Time after Calculation is ended; but an Eclipſe of the Sun muſt be culated for every different Meridian to obtain its true A pearance: wherefore, change the Time of the true Conjun on by the Tables into the Time proper to the other Meri by allowing its Difference, to which Time and Place, find Parallaxes *&c.* for the Parallax of the Moon differs in e Climate, on which Parallax the viſible Eclipſe of the Sun p cipally depends.

19. In Lunar Eclipſes, there being a true Loſs of Light, no matter from what Place of the Earth it is ſeen, it will be the ſame, but in Solar Eclipſes, there being no true Los Light in the Sun, and no more, than an Intercepting of Light, by the Moon coming between, it will neceſſarily different; according to the different Poſition of the Obſer 'tis not the Sun, but part of the Earth, over which, the Mo Shade paſſes, is in Darkneſs, and therefore ſome call it ra an Eclipſe of the Earth.

20. The Calculation of a Solar Eclipſe is much more D ficult, than that of a Lunar; becauſe in a Solar Eclipſe, th is ſo great Difference betwixt the Parallaxes of Sun and Mo according to their different Altitudes. nay during the wh Time of the Eclipſe, they are changeable and perpetually v ed, both in Longitude and Latitude. likewiſe from which A malies of Appearances we being free in Lunar Eclipſes, th Calculation muſt needs be more eaſy and exact.

21.

21. In Lunar Eclipſes, the Moon enters the *Weſt* part of the adow, with the *Eaſt* part of her Limb, and in the End, ſhe ves the *Eaſt* part of the Shadow, with the *Weſt* part of her mb; but in Solar Eclipſes, the *Eaſt* Limb of the Moon will t cover the *Weſt* Limb of the Sun, and the *Weſt* Limb of the on, will laſt uncover the *Eaſt* of the Sun, the Sun's Eclipſe ſes ſooner to thoſe that inhabit the *Weſt* parts, and later to ſe more *Eaſterly*, becauſe the Moon's proper Motion from *Weſt* to *Eaſt*, is ſwifter than the Suns, near 13 Times, and there- e it begins on the *Weſt* Limb of the Sun, which Part is firſt- ored to Light again, and if the Moon's viſible Latitude be *rth*, the *North* Part; but if *South*, the *South* Part of the Sun is kned, becauſe the Moon intercepts the Light of the ſame Side the Ecliptic the Moon appears.

22. There are, reſpecting the whole Earth, more Eclipſes of the n than of the Moon; but in reſpect of any one given place of Earth, there are much fewer viſible Eclipſes of the Sun, than the Moon, for the Shade of the Moon, is leſs than the Shade the Earth, and conſequently the Former will not ſo often volve any given Place of the Earth, as the latter will ſome t of the Moon: The Moon oftner takes away the whole Sun m the Earth, than the Earth takes away the whole Sun from Moon; the Body of the Earth being larger, receives more anſits of the Moon's Shadow, than the Moon of the Earth's Sha- w, and becauſe the Sum of the Semidiameters of the Moon, Earth is never leſs than 54 min. and the Semidiameters of Sun and Moon, never greater than 34 Min. the Eclipſe of Moon may happen in a greater Latitude of the Moon, than Solar, and in reſpect of one, and the ſame Place upon the rth, the Eclipſes of the Moon will be more frequent, tho' reſpect of the whole Earth, Solar Eclipſes may exceed in mber.

23. Becauſe for many Days together, the Sun's Place is once ry Year, but a little diſtant from either Node, during which me, there generally happen two *Syzygies*, in which the on will both hide the Sun from us, and the Earth will hide Sun from it, hence generally there are 4 Eclipſes, which are ater, the nearer any New or Full Moon, happens to the des. In a Year there ſeldom happens leſs than two or more, n 6 Eclipſes, and when two they are always of the Sun; one fore his Apogee, and the other after.

24. Sometimes the Sun may be eclipſed more than 12 Di and the Moon above 22, the Sun is ſeldom totally eclipſe one Place, the Moon often, and the greateſt Shadow of Moon, is not above 200 Miles, being the greateſt Differenc Diameters of the Sun and Moon, which according to the liquity of Horizons may be greater or leſs.

25. For the beſt, and exacteſt Method of calculating Eclip See Doctor *Gregory*'s Aſtronomy, Book 4. Sect. 7, 8. *Flam* Doctrine of the Sphere, at the End of Sir *Jonas Moor*'s Sy of the Mathematicks, alſo *Keil*'s Introduction to Aſtrono Lect. 13, 14. or Laſtly *Whiſton*'s Aſtronomical Lectures, which *Flamſteed*'s Tables for Calculation.

26. Eclipſes are not more frequent nor diſmal in our Ti than in Ages paſt, for where no Change is in Cauſes, ther neceſſarily no Change in Effects, nor in them is any thing O nous or Preternatural: being no more than the neceſſary ſult of the Motions of the Sun and Moon.

27. Solar Eclipſes are very different each from other, not ly becauſe of the unequal, and uncertain Motion of the Mo both true and apparent, the greater or leſſer viſible Latitu the Moon's Diſtance from the Sun, and unequal Diſta of both the Luminaries from the Earth: Hence the Eclip may happen pretty near the ſame Time and Place; yet t will not for the above Reaſons, be of the ſame Quantity, Duration; for this Rule is certain "The Heavenly Moti "are Incommenſurable among themſelves. nor have the ſa "Phænomena in every Reſpect return'd alike in any Place.

28. Eclipſes are of manifold Uſes in ſundry Branches of t Mathematicks, as Aſtronomy. Geography, Chronology, and N vigation, to correct their Tables, Maps, Globes, Account Time, and contribute very much to the Diſcovery of Long tude. both by Sea and Land; by the Wings of Eclipſes a Parallaxes. the Mind of Man flies up, and penetrates into t Cæleſtial Regions.

X. T

K. *To Obſerve the* ECLIPSE *of the* SUN, *without Hurting the* Eyes.

Some ſimply prick a very ſmall Hole with a fine Needle, in Sheet of Paper: Others uſe a Looking-Glaſs, but a better way with colour'd or ſmoak'd Glaſs, which defends the Eye from e Beams of the Sun, or by a Burning-Glaſs, reflecting it on clean Sheet of Paper, held twice as far from the Paper as r Burning.

Here follows an eaſy and cheap ASTRONOMICAL APPARATUS, *for Obſerving* ECLIPSES.

Prepare a Sheet of Paper, whereon draw a Circle about 6 ches Diameter, divide its Circumference into 360 equal Parts d its Diameter by 6 Concentric Circles into 12 equal Parts, for ſhow the Digits, and another Diameter for Decimal Parts to an 100, whereby the Proportion of the Light and Dark rts to each other, may be known: the 360 on the Limb y ſerve to determin the Inclination of the Cuſps of the ade, this paſte on a Board, which affix to a Teleſcope, ſo as be Perpendicular to its Axis, and at ſuch a Diſtance, that e Image of the Sun may exactly fill the outmoſt Circle of 360.

Then rule a Paper like a Surveyor's Field-book in 9 or 10 Co-mns for the Uſes mentioned in each Column.

Obſervations

Observations Common to the Eye, as	Number of Observations.	Digits and Parts.	Decimal Parts.	Time by Pendulum.	Time by Sun-Dial.	Sun's Altitudes.	Time Corrected.	Astronomical Observations, As
Appearances of the Sky.								Sun's Azimuth.
Color of the Eclipse.								Inclinati. of the Cusp
Stars seen.								Semidiameter of the whether.
Candles lighted.								Bigger or Less, than the Sun's Semidiameter.
Birds flying to their Nests.								Whether encreases, decreases.
								Whether the Moon has an Atmosphere, especially to be observed in total Eclipses of the Sun, by red streaks of Light just before and after, the said total Darkness.
								How long such are visible.

Being thus furnish'd, get a Room well darkn'd, and let no Light into it any where, but thro' the Telescope, which is sometime before the Eclipse begins, on a Surveying Instrument or the like with a Ball and Socket; that it may move higher or lower, or to any Point of the Compass to suit the Sun's Altitude and Azimuth, then appoint one to attend the Commencement of the Shade, its Progress Increase and Decrease, both Digits and Decimal Parts; let another watch the Time by the Pendulum, Watch, or Clock: a third mind the Sun Dial both Hours and Minutes: a Fourth mind the Sun's Altitude by a large Quadrant, or by a Gnomon, and End of its Shadow, whether Wall or Stake, all which Accounts, register in their proper Columns, principally noting not only the Beginning and End of the Eclipse, but also of total Darkness, when also each Digit is eclipsed, and Angle of Incidence, if the Air be clear, and will permit.

A Table

I. A Table Of the Stations of the Planets.

	Angle at the Sun when Stationary to Retrograde.	Days Retrograde.	Angle at the Sun, when Stationary to Direction.	Degrees Retrograde.	Elongation of the Sun, when beginning to be Retrograde.	Greatest Distance of the Sun in Opposition.	Elongation of the Sun, when beginning to be Direct.	Angle at ☉ of ♄ ♃ ♂, when in ☍ to the Sun.	Angle at the Sun of ♄ ♃ ♂, when in ☌ with Sun.
☽	66	140	66	7	108	180	108	180	0
☿	53½	120	53½	10	116	180	116	180	0
♀	22½	80	22½	♋ 20 ♌ 15 ♓♒ 10	135	180	135	180	0
♂	15	44	15	18	28	48	28	180 ☍ Sun when Retrogra.	0. ☍ ☉ when Direct.
♃	32	24	32	♍ 16 ♎ 8½	22	28	22	180 ☍ Sun when Retrogra.	0. ☍ ☉ when Direct.

The middle Direction happens in the ☍ with the Sun, and e Stations in or about the Octants: the middle Retrogradati- ns in the Oppositions, and that they always fall thus, and ne- r at other Times, is a thing that neither is nor can be deni- . *Fromondus*, one who was averse enough to the Annual otion of the Earth, saith, *The Annual Motion of the Earth is intain'd by the* Copernicans *by no Argument more Probable and* Specious

ſpecious, than that of the Station, Direction, and Retrogradation of the Pl
nets. For 'tis plain if the Spectator remain unmoved, tho' o
of the Center, and thereby equal Motions may appear uneq
yet the Object can never be ſeen to go backward, or ſtand ſt
unleſs the Place of the Spectator is likewiſe moved.

Becauſe the Retrogradations of the Planets, are not real i
themſelves; but only appear ſo to us at the Earth, cauſed b
the Earth's Motion; therefore by Reaſon of the various Poſi
ons of the Earth at different Times there cannot be any certa
univerſal and perpetual Rule given in Numbers: yet the fo
going Table will be ſerviceable, of which the Title of ea
Column is a ſufficient Explanation.

Finally, Tho' the Planets by their proper Motion advance fro
Weſt to *Eaſt*; yet ſometimes they ſeem to tend the contra
Way, from *Eaſt* to *Weſt*; before which Change they ſeem t
reſt a while, tarrying ſome Days in the ſame place, their Mo
on is very unequal, their ſwifteſt Progreſs when in Conjunc
on with the Sun: and their ſwifteſt Regreſs, when in Oppoſi
on, at which Time their apparent Magnitudes conſiderably e
creaſe, eſpecially in *Mars* and *Jupiter*. Tho' all theſe Planets a
to be found in the Bounds of the Zodiac, yet ſeldom are the
in the Ecliptic Line it ſelf; but decline *North* and *South* fro
it; which Latitude or Deviation is different amongſt them a
and tho' the Places wherein theſe Planets cut the Ecliptic d
continue the ſame, with reſpect to the Fixed Stars, yet th
go forwards continually in the Signs of the Zodiac, Alſo th
places, where their true Motion is ſloweſt or ſwifteſt, contin
the ſame with reference to the Fixed Stars; but as to the Ecli
tic, they ſeem to be transfer'd *in conſequentia*. Alſo the Sup
rior Planets *i. e. Saturn, Jupiter, Mars*, may form to us all A
pects with the Sun, yet the Inferior *Venus* and *Mercury* form no
ſo much as a Sextile; none but a Conjunction, which is eithe
in the upper or oppoſite Part of their Orbits, and ſometime
tho' ſeldom, both *Venus* and *Mercury* may be interpoſed betwi
the Sun and Earth in the form of Spots upon the Diſcus or Bo
dy of the Sun, as aforeſaid.

A Synopſ

XII. *A* Synopsis *of the* Satellites, *or* Moons *of* Saturn, *and* Jupiter.

Names.	Distance from him	Periodical Revolu.	Magni.
SATURN'S.	*English* Miles.	D. H. *l.* *ll.*	
, and next Satel.	146 000	1 21 18 26½	
2	187 000	2 17 41 10½	
3	263 000	4 12 25 10	
4	600 000	15 22 41 28	
5 and outmost.	1. 800 000	79 7 46 0	
JUPITER's			
, and next Satel.	300 000	1 18 28 36	2
2	364 000	3 13 17 54	3
3	580 000	7 3 59 36	1
4 and outmost.	1. 000 000	16 18 5 12	4

* This 4th Satellite may have Latitude, so as to free it from ling into *Jupiter's* Shadow, as in the Year 1684, *October*, *No-ber*, and *December*, else every Satellite in one Revolution, twice hid from us; besides when it falls into *Jupiter's* Sha-w, *First*, when in Conjunction with *Jupiter*, 'tis as a Spot be-een us and *Jupiter*. *Secondly*, when Diametrically opposite *Ju-er's* Body may interpose and Eclipse it, tho' the Shadow of *piter* be intirely free from it.

XIII. *The* Phænomena *of the* Satellites *or* Moons *or* Attendants *of* Saturn *and* Jupiter.

1. Theſe Secondary Planets fall ſhort of their Principals in reſpect of Magnitude; that before the Use of Teleſcopes, which was not until the laſt Age, they were wholly unſeen and unknown.

2. They do not always offer themſelves to the Sight of him that looks thro a Teleſcope; but do ſometimes wholly lie hid.

Becauſe they may be eclipſed by their Principals, or one another, or may be in the Shadow of their Principals, or when between us and their Principals will appear as a Spot hard to be diſtinguiſhed; ſuch Eclipſes happen to them after the ſame Manner as they do to our Moon.

3. Theſe Moons in general are each of them on both Sides its Principal, that is, are ſo ſucceſſively ſometimes on the Right, ſometimes on the Left.

Becauſe they revolve about their Principals.

4. They are continually changing their apparent Diſtances from their Principals, and wander from them ſeveral Ways.

For the Reaſon mentioned in the laſt.

5. Every one of them hath its certain proper Limits of Excurſion, which it never goes beyond, and which are alſo altogether different from the Limits of other Planets of its kind.

Which ſhows the Diverſity of the Curvilinear Paths, wherein ey ſeverally circulate about their Primary ones.

6. Theſe ſmall Planets in their Motion go by turns e contrary Way, to that which their Principals go, ey ſeeming to us ſometimes to tend from *Weſt* to *aſt*, and ſometimes again from *Eaſt* to *Weſt*.

Which they muſt needs do to us, who view them far with- t the Compaſs of their Orbits, whereas to an Eye placed in eir Primary's, they would both in Truth and Appearance re- olve perpetually towards the ſame part of Heaven.

7. Their Periodical Times, in which they return to e ſame Place in reſpect of their Principals, are the nger, when the Limits of their Excurſions are the rger, and their greateſt Elongation is greater than at of others.

This holds in both Primary and Secondary Planets, without ception, that which is more remote from the Center of Mo- on, takes up a longer Space of Time in its Revolution.

8. They are often ſeen not only without the Plane the Ecliptic; but alſo without the Annual Planes their Principals, and declining from both a little, ther to the *North* or *South*.

Even as Primary ones do in like manner.

9. Yet, this notwithſtanding, the Circum-Jovials ap- ear amongſt themſelves in almoſt the ſame Plane, hich alſo is proper to them, and the Circum-Satur- ials, likewiſe have a peculiar Plane, in which they moſt all of them are.

10. The greateſt Elongation of every Secondary om its Primary, remains always almoſt the ſame

nor are these little Planets Subject to any considerable Variation in this Respect.

These Harmonical Motions and Positions are wholly to be ascribed to the Wisdom, and Pleasure of the great CREATOR.

11. Each of the two outmost Primary Planets have a good Company of Attendants, for *Jupiter* keeps no fewer than Four constantly by him, and *Saturn* Five in his Retinue, which is a Sight no less Wonderful, than Delightful; these Satellites, like our Moon, do always accompany their primary Planets in their Circuits round the Sun, and in the mean Time their proper Circulations about their Primaries, and therefore they will have the same Phases and Figures, that our Moon shows us: When they are in Opposition to the Sun they appear to *Saturn* and *Jupiter* bright and full, from thence receding they assume a Gibbous Shape, when they come to a quadrat Aspect, they look like Half-Moon's: Before, and soon after the Conjunctions they show themselves in horned Figures, and when they come to be joyned in the same Line with the Sun, they totally disappear.

12. These Satellites seen from the Earth, tho' they go at the furthest, but a little way from their Primaries: yet sometimes they approach them nearer, and sometimes remove a little further from them. *Plate 7. Fig. 7.* Let A B T be the Orbit of the Earth, in the Middle of which the Sun's resides. Let E F be a Portion of the Orb of *Jupiter*, in which Let *Jupiter* be in ♃, who keeps in the Middle of the Orbits of his four Attendants, these Satellites or Moons, when they describe the inferior Parts of their Orbits L M N seen from the Earth or Sun, will appear to have a Motion *Westward*; but while they are moving thro' the superior Portion

tions G H K, we obſerve them to move *Eaſtward*, according to their true Motions. Now when their viſible Motion is *Eaſtward*, they are twice hid from us, once in O behind the Body of *Jupiter* that is, in the right Line which joyns the Centers of the Earth and *Jupiter*, and again they vaniſh, and become inviſible, when they fall into the Shadow of *Jupiter*, or are in the right Line, which joyns the Centers of the Sun and *Jupiter*, and then they ſuffer Eclipſes, which are always when they are at their Full, as ſeen from *Jupiter*. Theſe Eclipſes happening in the ſame manner as they do to our Moon, by the Interpoſition of the Earth between the Sun and it.

13. When *Jupiter* is to the *Eaſt* of the Sun, and is ſeen in the Evening after Sun-Setting, that is, when the Earth is in A, they are firſt hid behind *Jupiter*; becauſe of their viſible Conjunction with *Jupiter* before they fall into his Shadow, and their Second Diſappearing is in the Eclipſe upon the entring the Shadow. But when *Jupiter* is more *Weſterly* than the Sun as he appears after Conjunction, when he is only ſeen in the Morning, that is, when the Earth is about B, then they fall into *Jupiter*'s Shadow at V, and are eclipſed before they are hid behind his Body in P. But when theſe Moon's have a Retrograde Motion, that is, when they are ſeen to go *Weſtward*, and deſcribe the inferior Parts of their Orbits, then they only once diſappear in Q when they cannot be diſtinguiſh'd from the Body of *Jupiter*; but when the Satellites ſeen from the Sun, are in their inferior Conjunction with *Jupiter*, or as ſeen from *Jupiter*, they are in Conjunction with the Sun, their Shadows will fall upon *Jupiter*, and ſome Part of the Disk of *Jupiter* will be in an Eclipſe, and a Spectator within the Shadow would obſerve a total Eclipſe of the Sun.

14. By

14. By the Motions and Eclipſes of theſe Moons the Parallax of the Annual Orb in *Jupiter*, and his Diſtance from the Sun may be eaſily known; for let P O R be the Orbit of any Satellite, for Example, the outmoſt, and ſuppoſe the Earth in the Point of its Orbit A, the Time muſt be obſerv'd when the Satellite lies hid behind *Jupiter*'s Body in O. For which Purpoſe, the Moment of Time muſt be careſully mark'd when he firſt diſappears, and then alſo the Moment he becomes again Viſible, the middle Moment between theſe two is the Time, when the Satellite is in O, or in the Line which paſſes thro' the Earth and *Jupiter*, after the ſame manner obſerve when the Satellite is in the Middle of an Eclipſe, or in the Middle of *Jupiter*'s Shadow, that is, when it is in V, by this means we ſhall have the Time it takes to deſcribe the Arch O V, and becauſe his Motion about *Jupiter* is equable, and his Periodical Time known, we can thence find out the Arch O V, for this Planet revolves about *Jupiter* in 402 Hours. Let us ſuppoſe the Time he takes to move from O to V be 12 Hours, ſay as 402 : 12 ſo are 360 to a 4th Quantity, which will be found to be 10° 44', and therefore the Arch O V is 10° 44'; But this Arch is the Meaſure of the Angle O ♈ V, or of the Angle, which is equal to it A ♈ S, and the Arch which meaſures this Angle is the Parallax of the Annual Orb, which therefore is known.

15. In the Triangle A ♈ S, we have the Angle at ♈, and alſo the Angle at A, the Elongation of *Jupiter* from the Sun, which may be had either by a Calculation from Aſtronomical Tables, or by Obſervation, beſides we have the ſide A S, the Diſtance of the Earth from the Sun, which we aſſume to conſiſt

onſiſt of 100,000 Parts. Since therefore in this Tri-ngle, we have all the Angles, and one Side by Tri-onometry, we ſhall find the other Sides, and par-icularly S ♈, the Diſtance of *Jupiter* from the un, ſo likewiſe we may find A ♈, the Diſtance f *Jupiter* from the Earth, which is always variable; ut to do this nicely, there ſhould be repeated bſervations with the beſt Teleſcopes, and Time-eepers.

16. By the Eclipſe of *Jupiter*'s Moon's, we are able o give a Solution of a *Problem*, which is the moſt Noble and Curious in Natural Philoſophy, and which annot but raiſe our Wonder and Amazement, that s,

Whether Light be propagated to us in an In-tant, or if its Motion be ſucceſſive; and if it takes ome Time to arrive from the Sun, or any diſtant Ob-ect to us. Now theſe Eclipſes do ſhew us, that there s no inſtantaneous Motion in Light, tho' it comes rom the Heavens to us with a prodigious quick Mo-ion, and incredible Celerity.

For if the Motion of Light were in an Inſtant, when the Earth at T at its greateſt Diſtance from *Ju-piter*, an Aſtronomer here would obſerve an Eclipſe of a Satellite at the ſame Moment of Time, he would do, were the Earth at X, at her nearer Diſtance to *Jupiter*, for according to this *Hypotheſis*, Light is propagated in the ſame Diſtance thro' all Spaces inde-finitely, whether near or never ſo much remote. But if Light takes up any Time for its Propagation thro' Space it will ſooner paſs thro' a ſhorter Space, than Greater, and therefore an Obſervator at X being near-er to *Jupiter*, than one at T, by the Diſtance X T, which is about equal to the Diameter of the Earth's Orbit,

Orbit, will ſooner obſerve the Eclipſe of a Satellite than a Spectator can do at T, and therefore from the Difference of thoſe Times, which is proportionable to X T, the Difference of Diſtances, we can collect the Velocity of Light; and ſo this Matter is in Reality: For whenéver the Earth is at its neareſt Diſtance from *Jupiter* the Eclipſes are found to happen ſooner than they do, when they are obſerv'd from T at a greater Diſtance, where they fall out ſenſibly later than they ought to be, according to our Aſtronomical Computations; theſe quicker and ſlower returns of Eclipſes having been obſerv'd for many Years, by the Sagacious *Romer*, with much Art and Diligence: upon them he founded this Argument for demonſtrating the ſucceſſive Propagation of Light, and by them he proved that Light, like all other Bodies in Motion, had a determin'd Degree of Velocity, and took a determin'd Time to move thro' a given Space; to which Opinion, the greateſt Part of Aſtronomers do now give their Aſſent.

The Particles therefore of Light, tho' their Minuteneſs be indefinite, and not eaſily to be imagined: yet they have a progreſſive rectilinear Motion, and are not diffuſed, as by the Waves of any Medium, or Fluid. *Romer* determines the Velocity of Light to be ſuch, that is reaches us here from the Sun in the Space of 11 Minutes, (others ſince, only 7 Minutes) but that Diſtance does not ſeem to be leſs than 50 Millions of Miles; which Space, Light paſſes thro' in ſo ſmall a Time; that ſo prodigious a Velocity cannot eaſily be conceived by us, which ſo much exceeds the Velocity of the ſwifteſt Bodies we know: for tho' the Earth has a very quick Motion round the Sun; yet its Velocity compared with the Velocity of Light is no more than that of a *Snail* in Compariſon of the Swiftneſs of the Earth.

XIV. *The*

XIV. *The* Phænomena *of* Saturn's-Ring, *One of the greateſt* Wonders *of Our* SOLAR SYSTEM.

1. The Body of *Saturn* it ſelf ſeparate from this ing is plainly Sphærical, and can yield us nothing f theſe Phænomena.

2. This Singularity of *Saturn*'s Ring would induce any to exempt this Planet from a Diurnal Motion; hich ſome have given it in about a Month's Time.

3. The Ring is about ſo far diſtant from the Body *Saturn*, as it ſelf is broad, and the Diameter of *Sa-rn* is about 68000, Miles and is in Proportion to the iameter of his Ring, as 4 to 9. Hence the Interval hich is betwixt the Ring, and the Body of *Saturn*, to hich the Breadth of the Ring is nearly equal, ariſeth about 21,000 Miles. *A ſtrange and extraordinary* hænomenon!

4. Both the Surfaces of the Ring are ſomewhat lane, like Fluids, or thoſe Bodies, which, tho' now ardned, have ſometimes been in a of ſtate Fluidity, as laſs, Ice; not unlike thoſe Regions of the Moon, which me call Seas.

5. The Thickneſs of this Ring is ſo ſmall, that it uns the Notice of our Aſtronomers; for when the lane of the Ring paſſes thro' our Eye, it can ſcarce e ſeen, leaving nothing but a ſmall Line, or Stroke f a Shadow paſſing over the Body of *Saturn*.

6. Altho' the broad Surfaces of the Ring reflect Light ſtrongly and copiouſly enough; yet the exterior Surface thereof, that of the Edge reflects little or no Light, but a Shade only, tho' of what Matter it conſiſts, we cannot yet conjecture.

7. As we know not yet, whether it be Solid or Fluid: neither, till we diſcover ſome Spots in it, can we diſcover its circular Motion; if Solid.

8. The Plane of the Ring is inclined to the Plane of the Ecliptic, in an Angle of about 31 Degrees, and its Nodes, or Interſections with the Ecliptic in this Age, about the Middle of the 21*ſt* Degree of *Piſces* and *Virgo*.

9. Seeing the Figure of this Ring is altogether Circular, there will be no Apſides; conſequently no Progreſſion of the ſame.

10. The Inclination of the Plane of the Ring to the Plane of the Ecliptic is in the Space of one Revolution of *Saturn* about the Sun, twice the greateſt of all, and as often the leaſt, and its Axis conſequently in the Compaſs of one Annual Revolution twice inclines it ſelf to that Plane, and twice returns to its former Poſition; as the like happens to the Moon and Earth.

11. Hence *Saturn* appears Solitary, and without this Ring, as often as he is found about the Nodes of the Ring; having only a ſmall Track of a Shadow croſſing his Body, as aforeſaid, as in the Year 1701.

12. The

12. The like Appearance muſt happen, when the Poſition of the Earth and Sun, is ſuch, that the Plane of the Ring protracted would paſs betwixt them; for at that Time only the obſcure Surface of the Ring is expoſed to the Eye of the Obſerver.

13. This Circular Ring muſt put on an Elliptic Form; but ſo much the leſs Elliptic, by how much further *Saturn* is diſtant from the Line of the Nodes; for a Circle, unleſs the Eye be in its Axis, degenerates into an Ellipſis, whoſe greater Axis will be equal to the Diameter of the Circle; but the leſs Axis will be equal to the right ſine of the Elevation doubled *i. e.* of the Eye above the Plane of the Ring; which being given, the Species of the Ellipſis, which will appear upon the Earth, will alſo be given and *vice contra*.

14. The various Phaſes of the Ring in each Revolution of *Saturn* about the Sun, return again in a Round, and certain Likeneſs of Phaſes, proceeding from divers Surfaces of the Ring, return in Half the Circuit, or within the Space of 15 Years.

15. The Ring begins firſt to be ſeen, when the Sun is elevated almoſt 4 Degrees above the Plane thereof, that is, when *Saturn*'s Heliocentric Place is diſtant about 7 or 8 Degrees from the next Node, before and after it is in it; which Interval of 15 Degrees, *Saturn* moves thro' in the Space of 15 Months; during which Space *Saturn* will be ſo long ſeen without his Ring.

16. The Diſappearance of the Ring is ſome-
times owing wholly and ſingly to the Poſition o
the Earth, which may be ſuch, that only the dar
Surface of the Ring can be ſeen the Inhabitant
of the Earth can no more ſee the Ring; than i
it was not illuſtrated at all, nor will it happen other-
wiſe when the Plane of the Earth is found in the ver
Plane of the Ring produced, or elevated only
little above it.

XV. O

XV. *Of the* Tranſits *of* Venus *and* Mercury *over the* Sun's *Diſk.*

A Table *of the Moments of Time, when* VENUS *will be ſo cloſely in Conjunction with the* SUN, *as to be ſeen within its* DISK *for* 1000 Years, *with that* Planets *Diſtances from the* SUN's *Center at the ſame* Moments.

In the Month of *November.*

Year	Time of Conjunct. D.	H.	*l.*	Diſt. from Center of ☉. *l.*	*ll.*	
918	20	21	53	6	12	B
1161	20	21	10	6	55½	A
1396	23	7	20	4	38	B
1631	26	17	29	16	11	B
1639	24	6	37	8	30	A
1874	26	16	46	3	3	B
2109	29	2	56	14	36	B
2117	26	16	3	10	5	A

In the Month of *May.*

Year	Time of Conjunct. D.	H.	*l.*	Diſt. from Center of ☉. *l.*	*ll.*	
1048	24	13	45	3	50	B
1283	23	8	14	5	31	A
1291	25	15	9	14	27	B
1518	25	16	32	14	52	A
1526	23	9	37	5	6	B
1761	25	17	55	4	15	A
1769	23	11	00	15	43	B
1996	28	2	13	13	36	A
2004	25	19	18	6	22	B

The

The like for MERCURY.

In the Month of *April.*

Year	Time of Conjunct. D.	H.	*l.*		Dist. from Center of ☉. *l.*	*ll.*	
1615	22	21	38	**	7	20	B
1628	25	5	15	*	9	25	A
1661	25	4	32	*	4	27	B
1674	26	12	29		12	28	A
1707	24	12	6		1	34	B
1720	26	19	43	*	15	21	A
1740	21	11	43		15	36	B
1753	24	19	20	*	1	19	A
1786	22	18	57	*	12	43	B
1799	26	2	34	**	4	12	A

In the Month of *October.*

Year	Time of Conjunct. D.	H.	*l.*		Dist. from Center of ☉. *l.*	*ll.*	
1605	22	8	29		12	48	A
1618	25	2	3	*	4	45	A
1631	27	19	37	*	3	18	B
1644	30	13	11		11	21	B
1651	23	13	20		11	26	A
1664	25	6	54	*	3	23	A
1677	28	0	28	**	4	40	B
1690	30	18	2		12	43	B
1697	23	18	11	*	10	4	A
1710	26	11	45		2	1	A
1723	29	5	19	*	6	2	B
1730	22	5	28		16	45	A
1736	30	22	53	**	13	5	B
1743	24	23	2	**	8	42	A
1756	26	16	36		0	39	A
1769	29	10	10		7	24	B
1776	22	10	19		15	23	A
1782 Nov.	1	3	44	*	15	27	B
1789	25	3	53	*	7	20	A

Those

Thoſe Tranſits noted with one * are in part Viſible
London, and thoſe that have Two, are wholly

At the End of 8 *Years*, VENUS *is revolv'd to the*
n, *if there be taken away from the* Moment *of the for-*
r Tranſit 2 Days, 10 Hours, 52 Minutes, *and* 30
conds. *But it moves then in a Path, which inclines*
re to the South, *than the Former, by* 24 Minutes, 45
conds.

At the End of 235 *Years, if there be added* 2 Days,
Hours, *and* 9 Minutes, VENUS *will again enter*
Sun; *but in a way more* Northerly, *by* 11 Minutes
Seconds: *But if the foregoing Year be Biſſextile,*
re are to be added 3 Days, 10 Hours, *and* 9 Mi-
tes.

At the End of 243 *Years*, VENUS *paſſeth over the*
n *again, only there are* 43 Minutes *to be taken away*
m the Time of the Former; but ſhe goeth more South 13
inutes, 8 Seconds: *But if the preceding Year were*
iſſextile, add 23 Hours 17 Minutes, *to wit, the Com-*
ment of the Ablatitious Time unto a whole Day, and
all theſe Appulſes to the Sun *in the Month of* Novem-
r, the Angle of the viſible Way with the Ecliptic *is* 9
egrees, 5 Minutes, *and* VENUS's *Horary Motion with-*
the Sun, 4 Minutes, 7 Seconds, *wherefore ſeeing the*
n's *Semidiameter is* 16 Minutes, 21 Seconds, *the*
reateſt Duration of the Tranſits of VENUS *will be* 7
ours, 56 Minutes.

XVI.

XVI. *Having the Year of the* Cycle *of the* Sun, Moon, *and* Indiction. *To find the Year of the* Julian Period.

Multiply 4845, by the Cycle of the Sun, and 4200 by the Cycle of the Moon, alſo 6916, by the Year of Indiction given.

Divide the Sum of theſe Products, by 7980, neglecting the Quotient, the Remainder will be the Year of the Julian Period required.

EXAMPLE.

In the Year 1719, Cycle of the Sun was 19, of the Moon 9, and of the Indiction 11 the *Firſt* Product *i. e.* 4845, by 19 = 92055, the *Second*, *i. e.* 4200 by 9 = 37800, and the *Third*, 6916, by 11 = 76076 the Sum of theſe Products, is = 205931; which being Divided by 7980, will have a Remainder of 6431 Years, the Year of the JULIAN PERIOD ſought.

XVII.

CONCERNING COMETS.

SECT. XVII.

1. BEsides the Planets already mentioned, there are other great Bodies that ſometimes viſit our Syſtem, which are a ſort of Temporary Planets; for they come and abide with us for a while, and afterwards withdraw from us, for a certain ſpace of Time, after which they again return. Theſe wandring Bodies are called *Comets*.

Of Comets.

2. The Motion of *Comets* in the Heavens according to the beſt Obſervations hitherto made, ſeem to be regulated by the ſame immutable Law that rules the Planets; for their Orbits are Elliptical, like thoſe of the Planets, but vaſtly narrower, or more Eccentric. Yet they have not all the ſame Direction with the Planets, who move from *Weſt* to *Eaſt*, for ſome of the Comets move from *Eaſt* to *Weſt*; and their Orbits have different Inclinations to the Earth's Orbit; ſome inclining Northwardly, others Southwardly, much more than any of the Planetary Orbits do.

3. Altho' both the Comets and the Planets move in Elliptic Orbits, yet their Motions ſeem to be vaſtly different; for the Eccentricities of the Planets Orbits are ſo ſmall, that they differ but little from Circles; but the Eccentricities of the Comets are ſo very great, that the Motions of ſome of them ſeem to be almoſt in right Lines, tending directly towards the Sun.

4. Now, ſince the Orbits of the Comets are ſo extremely Eccentric, their Motions when they are in their *Perihelion*, or neareſt Diſtance from the Sun, muſt be much ſwifter than when they are in their *Aphelion*, or fartheſt Diſtance from him; which is the Reaſon why the Comets make ſo ſhort a Stay in our Syſtem; and when they diſappear, are ſo long in returning.

5. The Figures of the Comets are obſerved to be very different; ſome of them ſend forth ſmall Beams like Hair every way round them; others are ſeen with a long fiery Tail, which is always oppoſite to the Sun. Their Magnitudes are alſo very different, but in what Proportion they exceed each other, is as yet uncertain. It is not probable, that their Numbers are yet known, for they have not been obſerved with due Care, nor their Theories diſcovered, but of late Years. The Antients were divided in their Opinions concerning them; ſome imagined that they were only a kind of *Meteors* kindled in our Atmoſphere, and were there again diſſipated; others took them to be ſome ominous Prodigies. But modern Diſcoveries prove, that they are Worlds ſubject to the ſame Laws of Motion, as the Planets are; and they muſt be very hard and durable Bodies, elſe they could not bear the vaſt Heat, which ſome of them, when they are in their *Perihelia*, receive from the Sun, without being utterly conſumed. The great Comet which appear'd in the Year 1680, was within $\frac{1}{6}$ part of the Sun's Diameter from his Surface; and therefore its Heat muſt be prodigiouſly intenſe beyond Imagination. And when it is at its greateſt Diſtance from the Sun, the Cold muſt be as rigid.

XVIII. *Of the* Number *of the* COMETS.

Within theſe 4 laſt Centuries have appear'd to us but 24 *Comets*, of theſe Doctor *Halley* ſuppoſes 3 of them, who have had their Orbits and Appearances ſo *very like*, and the Times of their Appearing ſo very *equal* to be in reality; but one and the ſame Comet, appearing at 3 ſeveral Times, and the like we may ſuppoſe of ſome others. That great Comet, that appear'd in 1680, 1681. was ſeen before in 1106, once before about 532, and alſo 44 Years before our SAVIOUR's Birth, and therefore they conclude the Time of its Periodic Revolution round the Sun, to be 575 Years. The Time of the Revolution of another Comet, which Aſtronomers ſuppoſe will appear again in 1758, is 75 Years, another which probably may be ſeen here again in 1789, makes its Ellipſis round the Sun in 129 Years. The Orbits of theſe 3 are deſcribed in *Plate* 9.

XIX. *To find whether a* COMET *has a ſenſible* Parallax.

Its Parallax is that Angle, under which the Earth's Semidiameter would appear to a Spectator in the *Comet*, which is bigger when near, and vaniſhes when far diſtant. Now a *Comet* juſt before it diſappears, goes ſo ſlowly, that it ſcarce ſeems to move, and it may be twice obſerv'd in this manner. *Firſt*, when it is very high above the Horizon, take any two *Stars*, between which, the *Comet* lies in a right Line parallel to the Horizon, which by extending a Thread directly before the *Stars* may be eaſily tried afterwards, when

the *Comet* approaches near to the Horizon, by extending the Thread, we must again try, if it keeps in a right Line between the same two *Fixed Stars*. Now if there be any sensible Parallax, which depresses the *Comet*, it cannot be seen in the same right Line as before, and therefore if it keeps the same Position, as to those *Stars*, it is a convincing Argument, that the *Comet* has no sensible Parallax, and must therefore be at a prodigious Distance from us.

These temporary Planets, like the Ordinary ones have a Change in their Motions arising from the Motion of the Earth, and for the same Reasons, appear sometimes Retrograde, sometimes direct, sometimes they move slower, and sometimes with a quicker Motion, and like our Earth, most of them have a dense and dark Atmosphere surrounding their Bodies, which weakens and blunts the Sun's Rays that fall upon them, but when it appears, the Kernel or Solid Body of the *Comet*, which when the Clouds are dispersed gives a splendid and brisk Light.

XX. *An easy* Method *of finding the* Course *of a* COMET, *by a* Celestial Globe.

Let there be every Day observ'd 4 *Stars*, which are round the *Comet*, and let 'em be such as the *Comet* may be in the right Lines, which joyns the two opposite *Stars*, which may easily be found out by the means of a Thread placed before the Eye, and extended over against the *Stars* and *Comet*, then upon a *Globe* in which are mark't these 4 *Stars* in their proper Places, extend one Thread Diagonally thro' two

opposite

oppoſite *Stars*, and another thro' the other two oppoſite *Stars*, where the Threads interſect, is the Place of the *Comet*, if this be daily done, and the Place of the *Comet* be every Day taken by this means we ſhall manifeſtly find out the Courſe a *Comet* takes in the Heavens, which will be found to be a great Circle, and having two Points of this Circle we ſhall find its Inclination to the Ecliptic, and the Places of the Nodes, for it is only obſerving where a Thread ſtretch'd thro' the two Points cuts the Ecliptic.

Altho' all the Planets have their proper Motions from *Weſt* to *Eaſt*, yet many *Comets* have been obſerv'd to hold on in a contrary Courſe from *Eaſt* to *Weſt* as aforeſaid, with a very great Degree of Velocity, ſuch was the Courſe of the *Comet*, which *Regiomontanus* obſerv'd, in 1472, that deſcribed 40 Degrees of a great Circle in one Day. Hence we can poſitively conclude, that there are no Vortices in the Heavens, elſe when the *Comets* enter within the Planetary Regions, they muſt neceſſarily be driven out of their Courſe, by the Rapidity of the Solar Vortex, as by a mighty Torrent, which near the Earth, is of ſuch Force, that it carries it above 20000 Miles in an Hour, and who can think that ſo Rapid a Stream, were there any, would not affect the *Comets*, and, when they have a Motion contrary to its Motion, ſoon deſtroy it.

XXI. *Of the* Tails *of the* COMETS.

The Tails of *Comets* grow bigger, as they deſcend to the Sun, and at the *Perihelions* they are biggeſt and as they go further off from the Sun, and cool by Degrees, the Tail leſſens, till at laſt it is contracted within the *Comet*'s Atmoſphere.

The

The great *Comet*, which appeared in the Year 1680 after its Departure from its *Perihelion* projected such a Tail as extended it self more than 40 Degrees in the Heavens, nor can this be a Wonder, for it was so near the Sun that its Distance from its Surface at the *Perihelion*, was but ¼ Part of the Diameter of the Sun's Body, and therefore the Sun seen from the Body of the *Comet* would appear to fill the greatest part of Heaven, and its apparent Diameter could not be less than 120 Degrees.

CONCERNING the FIXED STARS

SECT. XXII.

1. THE *Fixed Stars* are those bright and shining Bodies, which in a clear Night appear to us every where dispersed through the boundless Regions of Space. They are term'd *fixed*, because they are found to keep the same immutable Distance one from another in all Ages, without having any of the Motions observ'd in the Planets. The *fixed Stars* are all placed at such immense Distances from us, that the best of Telescopes represent them no bigger than Points without having any apparent Diameters.

The fixed Stars are at immense Distances from us.

The fixed Stars are luminous Bodies, like the Sun.

2. It is evident from hence, that all the *Stars* are luminous Bodies, and shine with their own proper and native Light, else they could not be seen at such a great Distance. For the *Satellites* of *Jupiter* and *Saturn*, tho' they appear under considerable Angles through good Telescopes, yet are altogether invisible to the naked Eye.

3. Although

3. Although the Distance betwixt us and the Sun is vastly large, when compared to the Diameter of the Earth, yet it is nothing when compared with the prodigious Distance of the *fixed Stars*; for the whole Diameter of the Earth's Annual Orbit appears from the nearest *fixed Star* no bigger than a Point, and the fixed Stars are at least 100,000 Times farther from us, than we are from the Sun; as may be demonstrated from the Observations of those who have endeavoured to find the Parallax of the Earth's Annual Orb, or the Angle under which the Earth's Orbit appears from the fixed Stars.

The Distance from us to the Sun is nothing in comparison of the vast Distance of the fixed Stars.

4. Hence it follows, that tho' we approach nearer to some fixed Stars at one time of the Year, than we do at the opposite, and that by the whole Length of the Diameter of the Earth's Orbit; yet this Distance being so small in comparison with the Distance of the fixed Stars, their Magnitudes or Positions cannot thereby be sensibly altered. Therefore we may always, without Error, suppose ourselves to be in the same Center of the Heavens, since we always have the same visible Prospect of the Stars without any Alteration.

As to appearance, the Earth may be considered as being in the Center of the Heavens.

5. If a Spectator was placed as near to any fixed Star, as we are to the Sun, he would there observe a Body as big, and every way like, as the Sun appears to us; and our Sun would appear to him no bigger than a fixed Star: and undoubtedly he would reckon the Sun as one of them in numbring the Stars. Wherefore since

The fixed Stars are Suns.

ſince the Sun differeth nothing from a fixed Star, the fixed Stars may be reckoned ſo many Suns.

The fixed Stars are at vaſt Diſtance from each other.

6. It is not reaſonable to ſuppoſe that all the fixed Stars are placed at the ſame Diſtance from us; but it is more probable that they are every where interſperſed thro the vaſt indefinite Space of the Univerſe; and that there may be as great a Diſtance betwixt any two of them, as there is betwixt our Sun and the neareſt fixed Star. Hence it follows, why they appear to us of different Magnitudes, not becauſe they really are ſo, but becauſe they are at different Diſtances from us; thoſe that are neareſt, excelling in Brightneſs and Luſtre thoſe that are more remote, who give a fainter Light, and appear ſmaller to the Eye.

The Diſtribution of the Stars into ſix Claſſes.

7. The Aſtronomers diſtribute the Stars into ſeveral Orders or Claſſes; thoſe that are neareſt to us, and appear brighteſt to the Eye, are called Stars of the firſt Magnitude; thoſe that are neareſt to them in Brightneſs and Luſtre, are called Stars of the ſecond Magnitude; thoſe of the third Claſs, are ſtiled Stars of the third Magnitude; and ſo on, until we come to the Stars of the ſixth Magnitude, which are the ſmalleſt that can be diſcerned by the naked Eye. There are infinite numbers of ſmaller Stars, that can be ſeen through Teleſcopes; but theſe are not reduced to any of the ſix Orders, and are only called *Teleſcopical* Stars. It may be here obſerved, that tho' the Aſtronomers have reduced all the Stars that are viſible to the naked Eye, into ſome one or other of theſe Claſſes; yet we are not to conclude from thence that all the Stars anſwer exactly to ſome or other of theſe Orders; but there

Of Teleſcopical Stars.

may be in reality as many Orders of the Stars, as they are in Number, few of them appearing exactly of the same Bigness and Lustre.

8. The antient Astronomers, that they might distinguish the Stars, in regard to their Situation and Position to each other, divided the whole starry Firmament into several *Asterisms*, or Systems of Stars, consisting of those that are near to one another.. These *Asterisms* are called *Constellations*, and are digested into the Forms of some Animals, as Men, Lions, Bears, Serpents, *&c.* or the Images of some known things, as of a Crown, a Harp, a Triangle, *&c.*

The Stars digested into Constellations

9. The Starry Firmament was divided by the Antients into 48 Images or Constellations; twelve of which they placed in that part of the Heavens, where in are the Planes of the Planetary Orbits; which part is called the *Zodiac*, because most of the Constellations placed therein resemble some living Creature. The two Regions of the Heavens that are on each side of the *Zodiac*, are called the *North* and *South* Parts of the Heavens.

Zodiac.

10. Some of the principal Stars have particular Names given them, as *Syrius*, *Arcturus*, *&c.* There are also several Stars that are not reduced in Constellations, and these are called *Unformed Stars.*

Unformed Stars.

11. Besides the Stars visible to the naked Eye, there is a very remarkable Space in the Heavens, called the *Galaxy*, or *Milky Way.* This is a broad Circle of a whitish Hue,

The Galaxy or Milky Way.

like Milk, going quite round the whole Heavens; and conſiſting of an infinite Number of ſmall Stars, viſible thro' a Teleſcope, tho' not diſcernible by the naked Eye, by reaſon of their exceeding Faintneſs; yet with their Light they combine to illuſtrate that part of the Heavens where they are, and to cauſe that ſhining Whiteneſs.

12. The Places of the Fixed Stars, or their relative Situations one from another, have been carefully obſerved by Aſtronomers, and digeſted into Catalogues. The firſt among the *Greeks*, who reduced the Stars into a Catalogue, was *Hypparchus*, who, from his own Obſervations, and of thoſe who lived before him, inſerted 1022 Stars into his Catalogue, about 120 Years before the Chriſtian *Æra* as aforeſaid. This Catalogue has been ſince enlarged and improved, by ſeveral learned Men, to the Number of 3000; of which there are a great many Teleſcopical, and not to be diſcerned by the naked Eye; and theſe are all ranked in the Catalogue, as Stars of the ſeventh Magnitude.

13. It may ſeem ſtrange to ſome, that there are no more than this Number of Stars viſible to the naked Eye; for ſometimes in a clear Night, they ſeem to be innumerable. But this is only a Deception of our Sight, ariſing from their vehement ſparkling, while we look upon them confuſedly, without reducing them into any Order; for there can ſeldom be ſeen above 1000 Stars in the whole Heavens with the naked Eye at the ſame Time; and if we ſhould diſtinctly view them, we ſhall not find one, but what is inſerted upon a good *Cæleſtial* Globe.

14. Alth

14. Altho' the Number of Stars that can be diſcerned by the naked Eye, are ſo few, yet it is probable there are many more which are beyond the reach of our Optics; for thro' Teleſcopes they appear in vaſt Multitudes, every where diſperſed throughout the whole Heavens; and the better our Glaſſes are, the more of them we ſtill diſcover. The ingenious Dr. *Hook* has obſerved 78 Stars in the *Pleiades*, of which the naked Eye is never able to diſcern above 7; and in *Orion*, which has but 80 Stars in the *Britiſh* Catalogue, (and ſome of them Teleſcopical) there have been numbred 2000 Stars.

XXIII. *The Principal* Phænomena *of the* Motions *of the* Fixed Stars, *with ſome brief* Solutions.

1. All the Stars as well the Fixed, as Erratic, with the whole Furniture of the Heavens, do riſe and ſet every Day, or appear to revolve from *Eaſt* to *Weſt*, in a Circular Motion, which is perform'd about the Axis of the World, and this along Line's *nearly* parallel to the Equinoctial.

For our Earth by turning about its own Axis, like the other Planets muſt needs preſent to our Senſes this Phænomenon, without the leaſt Circumvolution of the Heavens.

2. Beſides this general apparent Motion, which is perform'd daily, the Fixed Stars ſeem to move a quite contrary Courſe, ſeeing they change, and increaſe their Longitude; for thoſe Stars, which in the Time of *Hypparchus* were in the Beginning of *Aries* are now advanc'd into *Taurus* near $\frac{1}{12}$ of the

Ecliptic about a Degree in 70 Years, and that with an even Velocity.

Now if the Equinoctial Point *Aries* be a Fixed Point, then in reality the Stars muſt move; but if ſaid Point be moveable, as it may be, then the Stars need not move from it, but the Point it ſelf may go back from the Stars, which is certainly the more probable Caſe: and which the Moderns call the Præceſſion of the Equinoctial Points, a like Parallel is in the Moon and other Secondary Planets; whoſe Nodes go backwards by Degrees towards the antecedent Signs, and Sir *Iſaac Newton* has demonſtrated *a priori*, that the Nodes of the Earth ought to go backwards 50 *Seconds* every Year. Hence this as well as the former Motion of the Fixed Stars, is not real, but apparent only.

3. Altho' the Fixed Stars perpetually change their Longitude from the Beginning of *Aries*, yet their Latitude or Diſtance from the Ecliptic, they do in no wiſe change being now the ſame, as in the Days of *Hypparchus*.

For if the Fixed Stars do reſt, and the Plane of the Ecliptic remains unchang'd, the Præceſſion of the Equinoxes is perform'd without any Change of the Annual Motion of the Earth, as to the Plane of the Ecliptic: 'Tis neceſſary that the Latitude of the Stars, or their Diſtance from the ſaid Ecliptic ſhould unto this Day remain unvaried.

Whilſt the Poles of the World are moved about the Poles of the Ecliptic in *Antecedentia*, and paſs ſucceſſively thro' all the Points that are 23 *Degrees*, 29 *Minutes*, diſtant from theſe Poles, their Points themſelves, or rather the Fixed Stars that are in them, come towards the Poles of the World ſucceſſively, and ſeem to be carried in *Conſequentia*, and to deſcribe Circles, which are really deſcribed by the Poles of the World about the Poles of the Ecliptic, which being placed in Centers are alone at reſt; becauſe they keep the ſame Situation in reſpect to one another.

Therefore the whole Sphere of the Fixed Stars ſeems to move in *Conſequentia*, about an Axis paſſing thro' the Poles of the Ecliptic, and each Star apparently deſcribes a Circle Parallel to the Ecliptic

cliptic, by which Motion, the Latitude of the Stars is not hang'd.

The Plane of the Æquator makes a right Angle with the xis of the Earth; therefore by the Motion of its Axis, the ction of the Plane of the Æquator, with the Plane of the cliptic is moved round, wherefore the Equinoctial Points, ♈ nd ♎ move thro' the whole Ecliptic Line, in the Space of a- out 25000 Years in *Antecedentia*, which Period is called the reat Year, or *Annus Platonicus*.

4. The Diameter of the Fixed Stars, as beheld thro' Teleſcopes are very ſmall, and almoſt inſenſible: nd the Stars themſelves ſeem as ſo many Lucid oints.

This is manifeſt to ſuch, who uſe the largeſt Teleſcopes, which ut off the adventitious Rays of the Fixed Stars, which ap- ear to the naked Sight, and made the Antients ſuppoſe their iameter to be ſenſible, no leſs than ¼ of a Minute, before the ſe of Teleſcopes.

5. The Fixed Stars do wholly want a Diurnal Pa- allax; but have a ſmall Annual one.

For the Superior Planets want a Diurnal Parallax, and much ore may the Fixed Stars, which are far beyond them. octor *Hook*, was the firſt that pretended to diſcover the Annual arallax of the Fixed Stars; which *Flamſteed* fully confirmed by rrecting his Numbers from the Compariſon of 15 Sets of bſervations made for Seven Years together, that the Polar ar hath a leſs Latitude about the *Summer* Solſtice, than it hath out the *Winter*, by near ½ of a Minute, which is their Annual arallax ſought, preciſely 47 *Seconds*, for the greateſt of all, which near 5 Times the Sun's Diurnal Parallax. Hence the Diſtance the Fixed Stars will be found 9000 Semidiameters of the An- ual Orbit, for as 47 *Seconds* to the whole Sine: ſo is the Diameter the great Orb to the Diſtance of the fixed Stars. But in Ob- rvations of ſuch ſmall Angles leſs than a Minute, Errors are arcely to be avoided, and what a prodigious Difference would Miſtake of only 15 *Seconds* cauſe in this Computation, and who n be ſure, he has not committed ſuch an Error, and what In- rument is nice enough, to be ſure to ¼ of a Minute. *See Plate* VIII.

6. There

6. There is a Path in the Firmament of the Fixed Stars, which is much brighter than the reſt of Heaven, and is therefore call'd the *Milky Way*, 'tis extended thro' a conſiderable Part of Heaven, in the Form of a Circle of ſome Breadth.

The Teleſcope helps us to ſolve this, by diſcerning a vast Multitude of little Stars, which eſcape the Sight of the naked Eye, whoſe cloſe and confus'd Reflection of their Rays cauſes that Color.

7. The Number of the Fixed Stars, which may be obſerv'd by the naked Eye, is much under 2000; but by the Help of the Teleſcopes they are found to be 10 or 20 Times ſo many, and always by how much the more exquiſite our Teleſcopes are, by ſo much the greater Number of Stars may be diſcover'd: So that it is much to be queſtion'd, whether ever we ſhall obtain a certain, and fixed Number of them.

8. The Light of the Fixed Stars is more Strong and Lively by far, than that of the Planets, altho' their apparent Diameters be far leſs.

Becauſe the Fixed Stars, thoſe Glorious Suns at an indefinite Diſtance ſhine with their own *native*, and not with a *borrow'd* Light, ſuch as is that of the Planets and Comets, which are Opake Bodies, wholly deſtitute of Light in themſelves, and ſhine only by the Reflection of the Light of the Sun. For if the Fixed Stars as before computed be 9000 Semidiameters of the Annual Orbit off: the Quantity of the Sun's Light on them would be but 81,000,000*th* Part of that Light of the Sun, which is with us. What will it be then, when 'tis reflected from them to us, in which it muſt undergo a like Decreaſe as before, and in Reality become inſenſible.

9. The Fixed Stars ſeem to twinkle and ſparkle much more than the Planets.

This

This may be owing to our Atmoſphere, and the ſmall Atoms r Corpuſcles, which float up and down in the Air, for the igher a Star riſes above it, the Twinkling grows leſs, and why e Planets do not, is becauſe their Diameter are of that ſuf-ient Magnitude, that altho' ſome part of them be intercep-d from our Sight, by the Vapours interpoſing; yet the reſt f the Orb remains to be ſeen clearly without Interruption: ut the Orbs of the fixed Stars are ſo ſmall, and their Rays ſo rong and lively, that the leaſt Particle of Vapors do ever nd anon diſturb, and break off their Rays.

10. The Fixed Stars ſeem to be diſpoſed in the Hea-enly Spaces in no certain Order, but as it were by hance only.

There may be a certain orderly, and harmonious Diſpoſition f the Fixed Stars amongſt themſelves, when they are beheld om ſome other proper Place, altho' that Order appears not, hen they are ſeen from this Earth. 'Tis but meet and juſt, at from the excellent Order of all the nearer Bodies, which e may, and do ſee, we ſhould conclude, that the ſame holds ſo in ſome ſort or other in thoſe remoter ones, tho' our aſt Diſtance from them, renders us incapable at preſent of iſcerning the ſame.

Thus we would Judge of an Army of orderly well diſciplin'd oldiers at a Diſtance, which would appear to us in a confuſed anner, until we came near, and had a regular Proſpect of em, which we ſhould then find to ſtand well in Rank and ile, ſo doubtleſs of the Stars.

11. Certain wonderful Things are obſerv'd about e Syſtems of the Fixed Stars. New Stars are ſome-imes ſeen, and preſently diſappear, the ſame Stars re obſerv'd to change their Magnitude, or their plendor by turns, as ſhining ſometimes with a dul-er, ſometimes with a more vivid Light. *Laſtly*, the reat *Huigens* obſerv'd a certain Space in *Orions* word, much brighter than all the reſt of Heaven; hich notwithſtanding appear'd not to have any notable

notable Stars in it more than uſual; but ſeemed as it were to have a Gap in that Place, thro' which, it yielded a Proſpect into a more lucid Region.

'Twas the Appearance of a New Star made *Hypparchus* firſt of all ſet about compiling a Catalogue of them, ſince which many have been obſerv'd by *Tycho*, *Kepler*, *Hevelius*, *Bullialdus*, *Caſſini*, *Boyer*, *Montanar*, and others, as aforeſaid.

That in the Neck of the *Whale* appears and diſappears by Turns and is found to perform its Revolution in 330 Days; and ſeveral other Stars obſerv'd by *Caſſini* and others, which cannot be accounted for, but by ſuppoſing them Planets revolving about ſome Star or Sun.

'Tis our Lot to be born on a Planet near a Fixed Star call'd a Sun, and had we been born on a Planet belonging to another Fixed Star, we ſhould have taken that for our Sun, and counted our ſelves alſo in the Center of the Univerſe, and look'd on the Sun we have now as a Star of the firſt or ſecond Magnitude according to its Diſtance: and this Earth might have appeared ſometimes to us, as probably *Saturn*, *Jupiter*, *Mars*, and *Venus* do appear to the Inhabitants in other Planetary Syſtems, when they are at their neareſt Diſtance.

XXIV.

XXIV. *Having the* SUN's Place, *and a good* Pendulum Clock, *to find the Right* Aſcenſions *of all the* STARS.

Firſt, Adjuſt the Clock, ſo as to run thro' the 24 Hours in the Space a Star leaves the Meridian, till it arrive at it again, which Time is ſomewhat ſhorter than the Natural Day; becauſe of the Space, the Sun ſeems to move thro' in the ſame Time *Eaſtward*.

Then when the Sun is in the Meridian, fix the Hand to the Point, from whence we are to begin to reckon our Time, and then obſerve when the Star comes to the Meridian, and mark the Hour and Minute the Hand ſhows, which turn into Degrees, and Minutes of the *Æquator* will give the Difference between the Right Aſcenſion of the Sun and Stars, which Difference added to the Right Aſcenſion of the Sun will give the Right Aſcenſion of the Star.

Now if we know the Right Aſcenſion of any one Star, we may from it find the Right Aſcenſion of all others, which we ſee: by marking the Time by the Clock between the Arrival of the Star, whoſe Right Aſcenſion we know to the Meridian, and another Star, whoſe Aſcenſion is to be found, the Time converted into Degrees and Minutes of the *Æquator* will give the Difference of Right Aſcenſions, from whence by *Addition*, we collect the Right Aſcenſions of the Star, which was to be found out.

CONCLUSION.

CONTAINING

Some moral Reflections *and* Inferences, *drawn from the aforesaid* Diſcoveries.

SECT. XXV.

An Idea of the Univerſe.

THoſe who think that all theſe glorious Bodies were created for no other purpoſe, than to give us a little dim Light, muſt entertain a very ſlender Idea of the Divine Wiſdom; for we receive more Light from the *Moon* it ſelf, than from all the *Stars* put together. And ſince the *Planets* are ſubject to the ſame Laws of Motion with our *Earth*, and ſome of them not only equal, but vaſtly exceed it in Magnitude, it is not unreaſonable to ſuppoſe, that they are all habitable Worlds. And ſince the *Fixed Stars* are no ways behind our *Sun*, either in Bigneſs or Luſtre; is it not probable, that each of them have a Syſtem of *Planetary Worlds* turning round them, as we do round our Sun. And if we aſcend as far as the ſmalleſt Star we can ſee, ſhall we not then diſcover innumerable more of theſe glorious Bodies, which now are altogether inviſible to us? and ſo *ad infinitum*, thro the boundleſs Space of the Univerſe. What a magnificent Idea muſt this raiſe in us of the *Divine Being*! Who is every where, and at all Times preſent, diſplaying his Divine Power, Wiſdom and Goodneſs amongſt all his Creatures!

As the Diſtance from us to the Moon is little in compariſon of our Diſtance from the Sun, ſo the Diſtance of the Sun from us is little in reſpect of the Diſtance of the Fixed Stars from us: in compariſon of which Suns our whole Earth bears no more Proportion than a Pin-head to a large Globe. Let then the proud Man conſider, and obſerve how little the whole Earth is in compariſon of the Heavens, and how ſmall a Dominion he has, were he Lord of that, whereas what he commands is not in compariſon, ſo much as an *Ant-Hill*, nor himſelf any other, but even as an Emmet crawling upon it, and

Subject

Subject upon every Accident to be ſquaſh'd to Dirt; ſurely this Conſideration will cauſe him to humble himſelf under the mighty Hand of God, and not to deſpiſe the meaneſt of his Fellow-Creatures.

Hence we may learn not to overvalue this World, nor to ſet our Hearts too much upon it, or upon any of its Riches, Honours or Pleaſures, for what is all our Globe; but a Point a Trifle, to the Univerſe. a Ball not ſo much as viſible among the greateſt Part of the Heavens, namely the Fixed Stars.

Is this that Point, which by Fire and Sword is divided among ſo many Nations? O! how Ridiculous are the Bounds and Purſuits of Ambitious Mortals.

An Emperor indeed may look Big, if he compare himſelf with a Centinel, and ſo may he if compared with a *Peaſant*, and a *Peaſant* if compared with Brutes, and they if compared with *Inſects*; but the Emperor compared with him, that made the Sun; that rides on the Chariot of the Wind, and hath the Clouds for the Duſt of his Feet, who meaſures the Heavens, as with a Span, and upholds the Pillars of the Earth: he diſappears or is next to Nothing, ſcarce a Ray of that incomprehenſible Divinity, whoſe Glory fills the Heavens, and Heaven of Heavens cannot contain, whom Million of Angels, with Unity and Harmony adore.

And ſeeing we have little Light, and as little Heat from the Fixed Stars: 'Tis hard to conceive what ſo many great Bodies ſhould be made for; if not to give Light and Heat to the Inhabitants of the Planets about them, which infinitely magnifies the Power of the Supreme Being.

They ſeem to have a too narrow and contracted View, that confine Mankind to this Earth, its highly probable, the Almighty hath Millions, that Worſhip him on other Planets, perhaps more pure and perfect than we are, and tho' the greater part of Men on this Earth were miſerable, which ſome know not how to reconcile with the Divine Goodneſs; yet their Number compared with thoſe that are Happy in other Parts of the Creation may be but as one to 10,000. who, it may be ſaid, do all poſſeſs Heaven on Earthly Planets.

There are likewiſe 10,000 Things both in the Microcoſm of our Bodies, and the Macrocoſm of the Heavens and Earth, the Knowledge whereof hath been reſerv'd for the latter Times, which calls for a due Improvement from us, and ſhould teach us, that he is a GOD of infinite Knowledge, for ſure He that formed our Body underſtands *Anatomy*, and He that made the Heavens, underſtands *Aſtronomy*, and He that made the Eye, underſtands *Optics*, and He that makes the Herbs to grow, underſtands *Botany*, &c. that is in ſhort, *Known unto GOD are all his Works from the Beginning*, and they to whom he communicates the greateſt Meaſures of Knowledge are accountable for their Improvement.

A Train of ſuch immenſe, and numberleſs Bodies, what leſs than an Almighty Hand could find Matter ſufficient for? and then compoſe ſuch magnificent Works, which by infinite Wiſdom, are ſet at ſuch due Diſtances from one another, as not to interfere, claſh with, or diſorder one another. Nay ſo great is their Diſtance, ſo convenient their Situation; that they do not ſo much as Eclipſe one another, except Secondary Planets.

In the Heavens we have an admirable Oeconomy, obſervable throughout all the viſible Regions of the Univerſe in the mutual Aſſiſtances, and Returns, which one Globe affords the other, thus as the Moon gives us Light, we repay the ſame with one many Times greater &c.

If the great Creator, and Contriver of the Univerſe, hath thus Model'd and Methodized this part, this Syſtem of it, where we live, and behold the Order thereof, no great doubt can be made, but the ſame infinite Wiſdom hath done the like in the other Syſtems: alſo that every Syſtem is ſet at a due Diſtance from one another, and every Body in each Syſtem at its due Diſtance from their Sun or Fixed Star.

In the Planets revolving about their Axes, we may conſider, and find that an infinitely Wiſe and Kind, as well as Omnipotent Being, was the Orderer thereof, for were theſe Globes always to ſtand Still, which owe both their Light and Heat to the Sun, in this Caſe, one Half of each would be dazled and parch'd with everlaſting Day, whilſt the other would be involv'd in everlaſting Night and Darkneſs, and ſo agree to the State of no Animal or Vegetable.

As

As GOD's Works are manifeſt Demonſtrations of his Exiſtence, ſo they are no leſs of his Perfections: particularly of his infinite Power, Wiſdom and Goodneſs. As every Workman is known by his Works, ſo the Heavens this Glorious Scene of GOD's Works, plainly demonſtrate the Eternal Creators infinite Wiſdom to contrive, his Omnipotency to make, and his immenſe Goodneſs, in being ſo indulgent to all Creatures, as to Order all his Works for their Good.

Thus the Learned Apoſtle *Paul* argues, *Rom.* 1. 20. "The inviſible Things of GOD are clearly ſeen from the Creation of "the World, being underſtood by the Things that are made, "even his Eternal Power and Godhead.

Of the ſame Faith was the Royal Pſalmiſt long before, *Pſa.* 90. 2. Before the Mountains were brought forth, "or ever he had "Formed the Earth or the World, even from everlaſting to "everlaſting, He is GOD.

Hence we may infer, that there is a GOD, or Supreme Being, that this World has not been Eternal; but was Created by that Supreme Being, who is Eternal, and exerciſes a continual Providence over the Creatures he has made. that he is not a neceſſary, but a free Agent, that he is Intelligent and Omniſcient, that he is an Allwiſe, and that he is an All powerful Being, that he is Omnipotent, Immaterial and Immutable, that he is Good or Beneficent, that he is a Spiritual, Living, and active Being, that he is but One, and that he is therefore the alone Supreme Lord and Governor of the whole Univerſe.

O Lord how manifold are thy Works, in Wiſdom haſt thou made them all. *Pſalm* 104. 24.

Etiamſi omnia a Veteribus inventa ſint, tamen erit hoc ſemper novum, Uſus & Diſpoſitio inventorum ab aliis. Seneca, Ep. 64.

FINIS.

Juſt Publiſh'd by *S. FULLER*, at the *Globe* in *Meath-Street*, *DUBLIN*.

THE *DUTY* and *OFFICE* of a *LAND STEWARD*: Repreſented under ſeveral *plain* and *diſtinct* Articles, with an APPENDIX, ſhewing the WAY to PLENTY, wherein are ſeveral Directions for the Management and Improvement of a FARM. By *E. Laurence*, Land-Surveyor. With a SUPPLEMENT, ſhewing the true Method of keeping *Stewards Accompts*. By G. CLARKE. (Price Bound 2*s.* 6*d.*)

WARD's YOUNG MATHEMATICIAN's GUIDE, in Seven PARTS. I. Arithmetick, Vulgar and Decimal. II. Algebra, or Arithmetick in Species. III. Elements of Geometry. IV. Conic-Sections. V. The Arithmetick of Infinites. VI. Practical Gaging. VII. A New SUPPLEMENT, not in any former Edition, containing *Four* eaſy Methods of making *Logarithms*, *Sines*, *Tangents*, and *Secants*; with a DEMONSTRATION of the *Axioms*, and DOCTRINE of *Plane Trigonometry*, &c. (Price Bound, 5*s.*)

The LIFE of the SELF-TAUGHT PHILOSOPHER, *HAI EBN YOKDAN*, who lived in an uninhabited Iſland above 30 Years: Written in *Arabic*, and Tranſlated into *Engliſh* by *SIMON OCKLEY*, A. M. in which is demonſtrated, by what Methods one may, by the meer Light of Nature, without Converſe with Men or Books, attain the Knowledge of Things Natural and Supernatural.

A MATHEMATICAL MISCELLANY, in Four PARTS. I. An *Eſſay* towards the probable *Solution* of the Forty five ſurprizing PARADOXES in *GORDON*'s GEOGRAPHY. II. Fifty five New and amazing PARADOXES, ſome in Verſe, ſome in Proſe, with their SOLUTIONS. III. Anſwers to the Hundred ARITHMETICAL PROBLEMS left unanſwer'd in *HILL*'s ARITHMETICK, and *ALEXANDER*'s ALGEBRA. IV. Miſcellaneous Rules about forming ÆNIGMA's, QUESTIONS, the Doctrine of ECLIPSES, of PENDULUMS, the ÆQUATION of TIME, *&c.* (Price bound, 1*s.* 8*d.*)

A New and Correct Edition of the *Elements* of *EUCLID*, with Select *Theorems* out of *ARCHIMEDES*. By *A. TACQUET*. To which are added, *Practical Corollaries*, and various Uſes by *W. WHISTON*, and a large Appendix of *Practical Geometry*, with Forty new *Figures*, not extant in any former Edition. Price bound, 4*s.* 4*d.*

The BUILDERS CHEST-BOOK: Or, A COMPLETE KEY to the Five Orders of *Columns* in *Architecture*. Containing nine *Lectures*, wherein their ſeveral *Members*, *&c.* are diſtinctly conſider'd, according to the Practice of *Palladio*. Illuſtrated with 7 *Copper-Plates*. Being a neceſſary Companion for Gentlemen, or any Artificer concerned in Building. By *B. LANGLEY*, Author of the *Practical Geometry*. A Book of *Architecture* of a Moyder Price, of which, the above is a *neat* and *exact* Compendium. Price bound, a *Britiſh* Half-Crown.

THE ODES and SATYRS of *HORACE*, that have been done into *Engliſh* by the moſt eminent Hands. *Viz.* Earl of *Rocheſter*, Earl of *Roſcommon*, *Cowley*, *Otway*, *Congreve*, *Prior*, *Maynwaring*, *Dryden*, *Milton*, *Pooly*. With his ART of POETRY, by the Earl of *ROSCOMMON*. To this Edition are added ſeveral ODES, never before publiſhed.